

FOURTH LEES AND RAPER MEMORIAL LECTURE.

RECENT RESEARCHES 12

ON THE

ACTION OF ALCOHOL

in Health and in Sickness :

A LECTURE BY

G. SIMS WOODHEAD, M.A. (Cantab), M.D. (Edin.)

*Fellow of Trinity Hall, and Professor of Pathology
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DELIVERED IN

The Guildhall, Cambridge,

— ON —

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UNDER THE PRESIDENCY OF

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THE LEES & RAPER MEMORIAL LECTURESHIP.

The Lectures deal with the varied aspects of the Temperance Reform, and were designed to perpetuate the memory and continue the work of the late FREDERIC RICHARD LEES, Ph.D., F.S.A., and JAMES HAYES RAPER, both of whom were zealously engaged for over Sixty years in many departments of Temperance and Social Reform—Dr. Lees being a great Philosopher and Teacher, and Mr. Raper one of the foremost Orators of his time.

For list of the Lectures see page 3 of cover.

Recent Researches

ON THE

Action of Alcohol in Health and in Sickness ;

BY

G. SIMS WOODHEAD, M.A. (Cantab.), M.D. (Edin.),

Fellow of Trinity Hall, and Professor of Pathology in the
University of Cambridge.

The two men in memory of whom this lectureship was founded were both active workers in the temperance movement. They were not mere dreamers. They were thoroughly convinced that our national health, our national powers, and our national morale, are being undermined and depleted by intemperance, and they believed that it is necessary that efforts, and strenuous efforts should be made to stem what they deemed to be a destroying tide. They were both broad-minded men ; they gave themselves to the study of very different phases of what is now called the alcohol question, and were sincere and earnest students, not merely of the physical side of this question, but also of its social and moral aspects.

The trustees of the memorial fund, acting in the spirit that animated Dr. Lees and Mr. Raper, have always given the widest latitude to the men whom they have invited to lecture on their behalf, and I have the pleasant duty of thanking them for allowing me to exercise my discretion to the full in selecting my subject, and then in determining the method of its treatment.

Though no one can be more impressed than am I by the moral evil worked by intemperance you will, I know, allow me, for this evening, to leave that side of the question untouched, and to confine what I have to say to what may be called the physical aspect of the question.

Evils of Acute Alcoholism Early Recognised.

It has long been recognised even by the most superficial observers amongst medical men that alcohol taken in excess and over long periods is one of the great predisposing causes to certain diseases. It has also been recognised that under certain conditions alcohol might even act as an exciting cause of disease, certain pathological conditions appearing

to be inseparably associated with the action of alcohol taken in large doses. Indeed, from very early times various forms of insanity, of indigestion, of disease of the liver, and inflammation of the lungs, especially when fatal, have as a matter of course been ascribed to the action of alcohol. Were it necessary, I might quote to you passages from Celsus, from Sydenham, and from more recent physicians in support of this statement. We find, however, that though these earlier observers were convinced of the accuracy of their hypothesis, they had nothing but their own experience and observation on which they could depend, and they naturally found it difficult to convince others who had not the advantage of their wide experience that the use of alcohol, in what was termed excess, was a fruitful cause of disease.

This is not to be wondered at, for in the history of medicine we find that, although much was long known of the general and predisposing causes of disease, it is only within comparatively recent times that even the best-informed medical men have been able to lay their finger on what may be called the specific causes of individual diseases, and to associate exciting and predisposing causes by the study of the specific organisms associated with disease, by the study of the organism or the individual in which the disease takes place, and by the study of the interaction between one and the other. In the light of the knowledge gained of such interaction it has been found necessary to take in a study of the action of alcohol on protoplasm—the basis of organic life—generally, and then of its action upon the specific kinds of protoplasm.

Action of Alcohol on Protoplasm.

As I have pointed out elsewhere, and as I see Gowland Hopkins also insists, if we find that alcohol exerts a definite action upon the various kinds of animal and vegetable protoplasm, which can be studied outside the human body, and if at the same time we can obtain even a *small* amount of evidence that alcohol acts similarly on the human body, we are justified in assuming that the tissues of the human body react to and are injured by alcohol much as are the tissues that we can study directly, the difference, if any, being one of degree rather than of kind.

It has been said, sometimes, that the method of the study of the action of alcohol on the protoplasm or tissues of growing animals and plants is unscientific. Is this the case? Surely, if we are to study the effect of alcohol on the tissues and organs of the body, we must first, if possible, determine the action of alcohol in various doses and in various dilutions upon normal tissues in which we can, to a certain extent, control the conditions of experiment. Indeed, whilst it must not be assumed that certain substances, alcohol amongst them, which act as poisons to a single kind of protoplasm, necessarily act in the same way upon one another, we may, I think, accept it that,

should these substances exert a deleterious action upon many kinds of tissues and many kinds of protoplasm other than those of the human subject, they will probably be poisonous also to our more highly developed tissues. It must be remembered that experiments on this point have now been accumulating for some time. I shall here mention but a few of them as examples. J. J. Ridge¹ found that 1 part of alcohol in 100 of water, if used to moisten geranium or grass seeds, interferes with their germination; they sprout tardily, and if the use of this solution be continued, the plants grow slowly, and the green colouring matter (chlorophyll) on which they depend for their respiration, and partly for their nutrition, is not formed in proper quantity. In the case of the geranium, both growth and chlorophyll production are markedly affected, the 1 per cent. solution interfering with growth so seriously that, at the end of six weeks, plants so "watered" are about half the size of control plants; moreover they are delicate and sickly. Fresh-water organisms, the medusa, and the daphnia (water-flea), are rapidly killed by a solution of 1 part of alcohol in 4000 of water. Then, again, alcohol, even in weak watery solution or used as a vapour, arrests or interferes with the development of the eggs of organisms so widely apart in the scale of animal life as the blowfly, the frog,² and the hen. Rauber's experiments on animals and plants are also of interest, as, though dealing with the same question and in the same way, they are of later date, and cover a much wider field than that covered by any other series of experiments; further, they appear to have been carried out independently of any of the earlier observers. Rauber³ noted the influence of alcohol in various strengths upon different plants, and upon animals in various stages of development—on the hydra, on tape-worms, on earth-worms, leeches, crayfish, various kinds of fish, the Mexican axolotl, on birds and on mammals, including the human subject. He found that in 10 per cent. solution, with which he usually worked, alcohol acts as a definite protoplasm poison, all forms of cell life upon which he experimented being more or less affected; that plants become shrivelled and etiolated, animals intoxicated, and that aquatic animals soon succumb. Crayfish placed in a 2 per cent. solution of alcohol die in a few hours, perch in a similar solution soon become intoxicated, fall to the bottom of the vessel in which they are placed, and die, though, if they are transferred to pure spring water before death takes place, they may recover in the course of a few hours.

The direct poisonous action of alcohol upon protoplasm of all kinds is very marked. It appears, however, that the less highly developed the protoplasm the greater is the amount of alcohol required to arrest its activity—that is, to paralyse it. For this reason most of the experiments carried out on the circulatory system aim at

¹ "Alcohol and Public Health," 2nd ed., 1893, p. 26.

² Ridge, J. J., *Med. Temp. Rev.*, London, 1898, vol. I, p. 148.

³ "Wirkungen des Alkohols auf Tiere u. Pflanzen," Leipzig, 1902.

determining the reflex (or indirect) action of alcohol on the heart through the nervous system. Most of those who have made experiments on this subject have convinced themselves that comparatively small quantities of alcohol circulating in the blood and acting upon the nerve cells have a distinct effect in causing the heart's action to become abnormal. But the direct action also comes in. The heart, an organ constantly at work, one on which the body depends for the continuance of its organic life, is made up of muscular tissue, which, according to Ringer and Sainsbury,¹ appears to resist the action of exceedingly strong doses of alcohol. These observers maintain that an artificial blood must contain nearly 7 per cent. of ethyl alcohol before it can act directly upon (then paralysing) the muscular substance of the heart. They say that under these conditions the paralysis commences at once, and is never preceded by any evident stimulation to increased activity. Hemmeter² says that such doses kill the muscle of the heart instantaneously; for the present let us accept the lesser degree of toxicity as being the correctly determined one. This muscular tissue of the heart wall may be taken as representing ordinary protoplasm of normal functional activity and development as compared with the much more highly and later developed nerve cells.

It has already been stated that it required nearly 7 per cent. of ethyl alcohol to affect the individual muscle fibres of the heart of a dog,³ but it has been proved by experiment by Martin and Stevens (quoted by Monro and Findlay)⁴ that blood containing $\frac{1}{4}$ per cent. of ethyl alcohol so alters the protoplasm of these muscles that within a single minute there is a measurable diminution in the amount of work done by the heart, even when it is isolated from its external nerve-supply. If the strength of the solution be doubled, the activity of the heart may be so far diminished that it is scarcely able to drive out a sufficient amount of blood to supply its own nutrient arteries. Under these conditions the heart becomes abnormally dilated; it never contracts completely, and this condition becomes more marked as the administration of the alcohol is prolonged.

Action of Alcohol on Phosphorescent Protoplasm.

Looking round for some form of protoplasm in which changes in the functional activity might be readily noted, it struck me that Beyerinck's phosphorescent bacillus offered a protoplasm of low organisation, and one having a definite and easily-measured functional activity. When this bacillus is grown in fish broth and in the presence of air, it gives off a peculiar phosphorescent light readily seen with the naked

¹ *The Practitioner*, London, 1883, vol. xxx, p. 339.

² "Studies from the Biol. Lab., Johns Hopkins Univ., Baltimore, 1889," vol. iv., no. 5.

³ *Ibid*, 1887, vol. ii.

⁴ *Med. Temp. Rev.*, London, 1903, vol. vi., p. 325.

PHOTOGRAPHS OF PHOSPHORESCENT BACTERIA TAKEN BY THEIR OWN LIGHT.

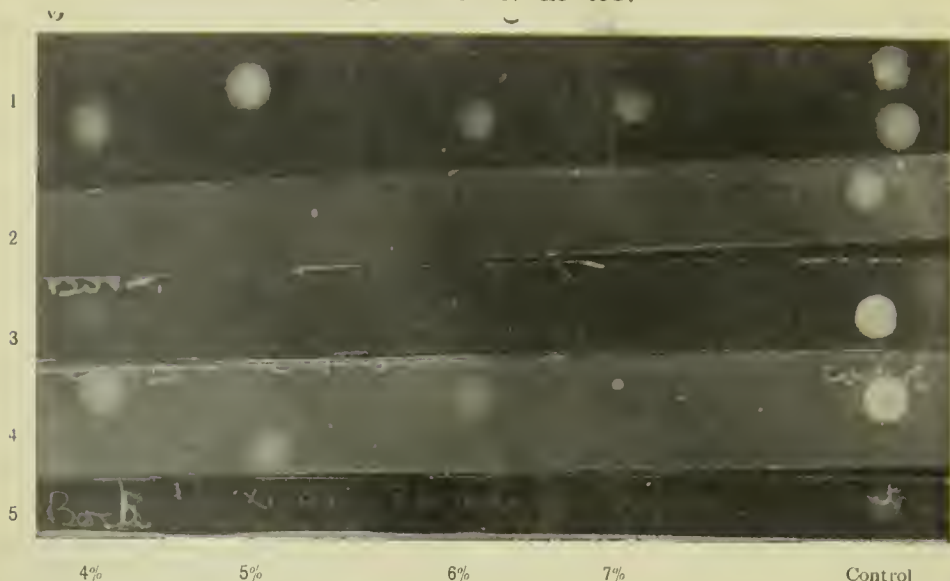


FIG. 1.—Measured Quantities of a brilliantly Phosphorescent Culture were put into Test-Tubes Alcohol added, and Contact Exposures made for varying Periods of Time.

1. Control (no alcohol added); exposure for 40 minutes. 2. Alcohol added, then exposure made=40 minutes. 3. Exposure made 24 hours after addition of alcohol; exposure=2½ hours. 4. Exposure made 40 hours after addition of alcohol exposure=6 hours. 5. Taken immediately after 4; exposure 20 minutes.

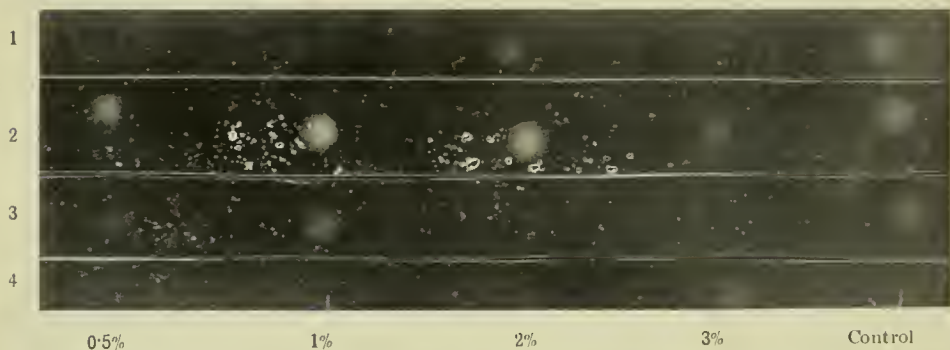


FIG. 2.—Measured Quantities of a Young and not very brilliantly Phosphorescent Culture were put into Test-Tubes, Alcohol added, and Contact Exposures made for varying Periods of Time.

1. Control (no alcohol added): exposure 20 minutes. 2. 2½ hours' exposure immediately after addition of alcohol. 3. 5 hours' exposure 24 hours after addition of alcohol. 4. 20 minutes' exposure taken immediately after 3.

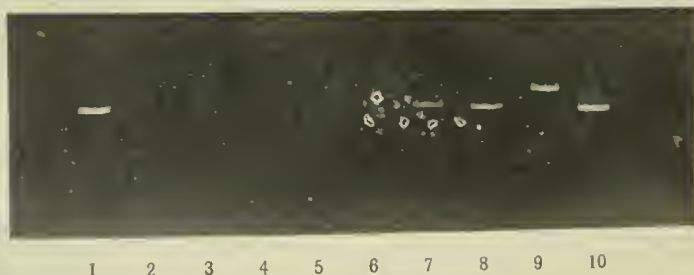


FIG. 3.—Measured Quantities of a brilliantly Phosphorescent Culture were put into Test-Tubes Alcohol added, and Exposure through Lens made for 24 hours.

1, Control (no alcohol added). In 2 to 9, alcohol added: 2, 7%; 3, 6%; 4, 5%; 5, 4%; 6, 3%; 7, 2%; 8, 1%; 9, 0.5%. 10. Control (no alcohol added).

[To face p. 5].

eye, and so actinic that permanent records of its activity may be obtained by photographic methods. What Ringer and Sainsbury were able to demonstrate as regards the protoplasm of muscle, we might be able to note in the protoplasm of this organism. After allowing the bacillus to multiply and grow until it produced a good glow in the broth, one of my assistants, W. Mitchell (to whom I am indebted for the careful way in which he has carried out these experiments and photographed the results for me), added to it various measured quantities of ethylic alcohol. The results of this experiment I throw on the screen (see Plate). When this broth culture of growing organisms is allowed to throw its beams of light on to a photographic plate, it is found that at the end of twenty minutes a very distinct image of the round hole through which the light is allowed to pass is obtained. On the addition of alcohol in quantities of from 12 down to 7 per cent., the light-producing function of the phosphorescent organisms is completely paralysed, and no image can be obtained even with a two and a half to three hours' exposure. The tube containing 5 per cent. alcohol gives a very faint glow that can just be photographed in two hours and a half. The 4 per cent. tube gives a slightly stronger image, as do also the 3 per cent. and 2 per cent. tubes, though the images are not so distinct as are those obtained on a twenty minutes' exposure from a tube in which there is no alcohol. When, however, we come to the 1 per cent. and $\frac{1}{2}$ per cent. tubes, there appears to be little difference as regards the density of the image obtained from these and that obtained on exposure to the control tube. It must be remembered that we are here dealing with a low form of protoplasm, and that the function of light production does not require anything like such complex conditions as are necessary for the continued life and activity of a nerve cell, and to that extent it will probably be far more resistant to the immediate action of alcohol.

Alcohol Kills Yeast Protoplasm.

It is well-known that in the process of fermentation the yeast organism continues to produce alcohol until this substance accumulates in the fermenting liquid up to a strength of about 13 per cent.; any liquor containing more than this amount of alcohol is recognised as being fortified by artificial means—that is, by the addition of distilled alcohol. The yeast organisms, from the very fact that they produce the alcohol, are probably capable of living in its presence longer than almost any other form of protoplasm, but even they become paralysed in the presence of 13 per cent. alcohol.

It may be accepted, then, that alcohol is a protoplasm poison, acting specially as a paralysing agent, interfering with the functional activity of the protoplasm, and ultimately causing its death.

Does Alcohol act as a Stimulant to Protoplasm.

In carrying out these experiments with the phosphorescent bacillus, I considered that it was necessary to determine whether, in the first

instance, alcohol might not exert some stimulating action upon the production of light by the bacilli. I formed the opinion from a series of preliminary experiments that this might be the case, but a more prolonged and accurate investigation led me to the conclusion that alcohol, introduced in comparatively small quantities into the tubes containing the light-producing bacillus, exerted little effect. As the organism manifests its special light-producing power only in the presence of oxygen, it is difficult—in fact, almost impossible, under the conditions of the experiment—to prevent rapid evaporation of the alcohol. The effect has therefore to be determined almost at once. Bearing these facts in mind, it cannot be wondered at that, as a 1 per cent. solution of alcohol did not inhibit or prevent the functional activity of these organisms at once, there was, owing to the rapid evaporation of the alcohol at the temperature of the incubator, no demonstrable action at a later period. A 7 per cent. solution of alcohol, however, was quite sufficient to inhibit the glow—the evidence of specific functional activity of the protoplasm of these organisms—just as a 13 per cent. solution is sufficient to prevent yeast from producing alcohol.

Action of Small Doses of Alcohol on more highly-developed protoplasm.

It must be remembered, however, that alcohol, like the metallic poisons, whilst acting in strong solution as a definite protoplasm poison, killing it rapidly, may in smaller doses act by simply lowering the vitality of the tissues or by diverting their functions into abnormal channels. For example, large doses of phosphorus bring about very rapid degenerative changes in the liver, kidney, heart, and certain other tissues of the body. A rapid fatty degeneration, so distinct and gross that it may be detected by the naked eye, comes on, and under the microscope the appearances presented are equally characteristic. Phosphorus in smaller doses, administered over a prolonged period, gives rise to less severe degenerative changes, but changes which may be almost equally well demonstrated both to the unaided eye and under the microscope. Certain metallic poisons in large doses also bring about acute tissue changes, whilst given in smaller quantities, but acting over prolonged periods, they induce a different set of tissue modifications. Similarly, alcohol in large doses acts quickly by causing fatty degeneration of the protoplasm; whilst in small doses, just as in the case of chronic lead-poisoning, it appears to act by inducing fibrous changes in certain organs,—the liver and kidney, such fibrous changes being in both cases associated with a more or less marked degeneration of the special tissues of these organs. It was only as the action of the well-recognised protoplasm poisons came to be understood that the two kinds of alcohol poisonings could be discriminated, and eventually more or less accurately described.

We may, then, accept it that all protoplasm, whether the basis of animal or plant life, is injuriously affected even by small quantities of

alcohol, and that under certain conditions there is such a marked interference with nutrition, power of movement, and reproductive function that even where immediate death of the organism as a whole does not supervene marked degenerative changes result, the animal or plant under these conditions living on a lower plane as regards power of movement, nutrition, and reproduction than does the healthy organism into which no alcohol has been introduced.

Action of Alcohol on the Blood Vessels.

Hutchison¹ and Monro and Findlay² have brought together an interesting series of facts relating to the action of alcohol on the cardiovascular system :—in the first place, as regards its strictly local effects; secondly, as to its reflex action. If a concentrated solution of alcohol be applied to the skin it is rapidly absorbed, and the blood vessels become distended. It is pointed out that this distension may possibly be due merely to the heat and moisture applied when precautions are taken to prevent evaporation of the alcohol. That this is not the case, however, is evident from the fact that the pressure in the artery supplying the part is raised much more by an alcohol compress than it is by a water compress. It has been noted also that the vessels of the abdominal wall are especially easily dilated by this local application of alcohol. Further, it has been found that the injection of alcohol directly into the circulating blood is followed by a dilatation of the blood vessel through which it passes. What applies in the case of the skin applies also in the case of the stomach. The lining membrane of the stomach becomes bright red as a result of the dilatation of the bloodvessels, and the secretion from the mucous membrane lining the stomach goes on more freely, though the fluid secreted appears, under these conditions, to be more dilute and less active than is the normal gastric secretion. Alcohol taken into the stomach is very rapidly absorbed and distributed to the furthest corner of the body, appearing in the blood within a couple of minutes of its ingestion ; it is present in the blood in highest quantity in about fifteen minutes from the time that it is administered. A single tablespoonful of alcohol taken into the stomach produces a temporary rise in the bloodpressure, an opening up of the bloodvessels in the mouth and in the stomach, often inducing a reflex rise in the blood-pressure.

Stimulation followed by corresponding Depression.

It is a curious fact, however, that this rise is of short duration, and is almost invariably followed by a fall below the original level ; this may continue for some time. Such rise in blood-pressure leads, of course, to an increased flow of blood through the brain, and it must be recognised that for a time small doses of alcohol may cause the brain to be more

¹ "Food and the Principles of Dietetics," London, 1892, p. 326 *et seq.*

² *Med. Temp. Rev.*, London, 1903, vol. vi., p. 325.

active, and may help to increase the mental output; it must be remembered, however, that, as Lauder Brunton and others have pointed out, the mere act of sipping cold water may have a similar effect in accelerating the flow of blood to the brain. In fact, any stimulation of branches of the nerves passing from the surface up to the brain is, as a rule, followed by an increased action of the heart with a corresponding increase in the amount of blood passed through the brain. An oft-quoted passage from Lauder Brunton¹ bears very closely on this point. "Individuals of all nations," he says, "when desiring to think more accurately, are accustomed to irritate some branch of this nerve (the fifth, the nerve supplying the face) either by scratching the head, rubbing the forehead or chin, striking the nose or taking snuff; chewing sweet or pungent substances has a similar effect in enabling some persons to think more clearly, while under similar circumstances alcohol is sipped by others." In the case of alcohol the increased activity has induced those who have taken alcohol to imagine that it has a specific action. This action, however, has nothing really specific about it; there is a difference in degree, no doubt, but none in kind, and it is interesting to note that just as the exaltation following the sipping of water is transient, and is followed by a certain phase of depression, so the more active exaltation produced by alcohol is followed by a more marked and more persistent depression.

This is a fact that can scarcely be too strongly insisted upon, as it accounts in great measure for the marked desire there is in men who depend upon alcohol for mental stimulus for a repetition of the stimulant at shorter intervals and in stronger form.

Alcohol Interferes with the Oxidation of Tissues.

Alcohol may be classed with certain poisons produced by the lower vegetable organisms (yeasts and bacteria), many of which act as protoplasm poisons, and have the power of combining rapidly with oxygen (the essential life-giving agent in fresh air), which under normal conditions would go to the tissues; further, they act by so altering the tissues that they become less capable of taking up such oxygen as has not been absorbed by the poison. The "oxygen hunger" of these poisons, of which we accept alcohol as a type, is so great that when taken into the body it interferes with the oxidation of the fat and carbohydrates ingested along with it.² The oxygen taken up by the blood as it passes through the lungs, is more or less rapidly seized upon by the alcohol with which it combines, with the result that none or little is left for the tissue protoplasm, and the nutritional or building-up processes are interfered with. Moreover, there is at the same time a serious interference with the excretion of waste products, and as a result of this an accumulation of further poisonous products in the

¹ "Text-Book of Pharmacology," etc., London, 1887, p. 769.

² Madden, *Amer. Med., Phil.*, 1901, vol. i., pp. 209, 258.

protoplasm. We have mentioned already that the maximum quantity of alcohol is found in the blood fifteen minutes after its administration. It may also be found in the other fluids of the body—the fluids bathing the tissue cells, supplying them with their nutriment, and removing from them their waste products. These fluids contain proteid, fat, and carbohydrates, which, under ordinary conditions, are assimilated by the protoplasmic cells. They also contain waste materials thrown out by the cells. Unaltered alcohol in this fluid, even in small quantities, certainly exerts a paralysing influence on the cells, as a result of which the processes of nutrition—assimilation and excretion—are rendered less active, and even such substances as are taken into the cells are only slowly and partially oxidised or burnt up; there is an accumulation of partially digested material as well as of waste products, and the cell is starved and “clogged” simultaneously.

Accumulation of Fat in the Tissues of Alcoholics.

In many alcohol-drinkers who are presumably otherwise healthy there is often an excessive accumulation under the skin of fatty or adipose tissue. This in itself is not recognised as an abnormal condition, but when in such cases we find a similar accumulation of fatty or adipose tissue, in the heart and liver, positions in which it is not present—permanently, at any rate—in healthy individuals, we begin to suspect the healthiness of the process. For example, fat may be found between the muscular fibres of the heart wall, or there may be a permanent accumulation of fat in the liver cells, a condition that normally should be present for a comparatively short time only, and at a definite interval after food has been taken and the process of digestion has commenced. In the patient who is taking considerable quantities of alcohol this fatty condition of the heart or liver may persist even after the patient has become thin and emaciated, the irregular process continuing for some time after the fat has disappeared from its more regular positions under the skin, and in what is known to the butchers as the “apron.”

Fatty Degeneration.

In these patients, however, there is often a fatty change of a much more serious character—a change in which the protoplasm, or organic basis of life, appears to undergo marked degenerative changes, fatty material being formed at the expense of this substance. This fatty change is almost identical with a condition demonstrated by Bauer¹ in the protoplasm of a starving dog. Such an animal, after using up all the fat normally present under the skin and sometimes stored up in the omentum, has to draw its further supply of heat-giving fat from important organs, such as the heart, liver, muscles etc., the active protoplasm of the cells of these organs being broken down into fat and

¹ *Zeitschr. f. Biol.*, München, 1871, Bd. vii., S 63, and 1878, Bd. xiv., S. 527.

waste nitrogenous substances. In these cases the animals gradually waste away. Certain other poisons—ether, phosphorus, arsenic, the coarser products of metabolism, and the products of disease-producing organisms—all act in the same way. Alcohol, therefore, may be looked upon as inducing changes similar to those set up by starvation, and by certain organic and inorganic poisons. A similar condition is induced by prolonged muscular exertion when insufficient time is allowed for rest and repair. Between alcohol-poisoning and starvation there is, however, this essential difference: in the latter much of the fat stored up under the skin, etc., is used up before the other cells of the animal are attacked, but in alcohol-poisoning this is not the case. Fatty degeneration of a most marked kind may occur in very stout patients in whom there still remains a considerable quantity of subcutaneous and omental fat in addition to that found between the muscular fibres of the heart and in the liver cells.

Fatty Degeneration, a Manifestation of Disease.

Further, from a doctor's point of view it is exceedingly interesting to note that the fatty degeneration observed in alcoholic patients is very like that met with in cases of diphtheria and other bacterial poisonings, and the more carefully these analogies are analysed, the more are pathologists who have devoted attention to this question convinced that the conditions set up by the poisons of disease-producing organisms and by alcohol are the same in many of their essential details, and that they usually run on parallel lines.

The Heart Affected.

Dr. Berkley,¹ an American physician, has been able to bring forward direct proof of this action of alcohol in causing fatty degeneration of the heart, so fruitful a cause of heart failure. In making a series of experiments on acute and chronic alcohol-poisoning in rabbits, he found, in four cases out of five of chronic alcohol-poisoning in these animals, fatty degeneration of the heart muscle, a condition which, he says, "seems to be present in all animals subjected to a continual administration of alcohol in which sufficient time between the doses is not allowed for complete elimination."

Cowan,² in an admirable work on fatty degeneration of the heart, points out how badly alcoholic cases "bear acute disease, failure of the heart always ensuing at an earlier period than one would anticipate"; and, in summing up the causes of fatty degeneration, he speaks of the presence of a toxic agent in the circulating blood or in the fluid contained in the small nutrient spaces between the tissues of the heart as being one of the most important factors in its production. Amongst such poisonings or toxic conditions he gives a prominent place to phosphorus, arsenical and chloroform poisoning, alcoholism, uræmia,

¹ *Journ. Hopkins Hospital Reports*, Baltimore, 1897, vol. vi., p. 30.

² *Journ. of Path. and Bact.*, Edin. and London, 1902, vol. viii., pp. 177-198.

ete. Weichselbaum of Vienna maintains exactly the same thesis. Muir accepts Cowan's work and conclusions, in fact, most pathologists take the stand that alcohol acts as a definite poison on the protoplasm of the heart muscle, the nutrition of which suffers, marked degenerative changes of a fatty nature being induced.

The Heart in Rheumatic Fever.

Dr. Mitchell Bruce¹ has called attention to the fact that the direct effects of alcohol on the heart and vessels are so "complicated with the many indirect effects which it produces on these organs, by deranging the the functions of alimentation and assimilation, the nervous system and the kidneys, and with the secondary effects on the vessels and heart of chronic nephritis, due to the same cause, that it is difficult to determine which are direct and which are indirect." He states, however, that dilatations of the heart and alterations in the myocardium are often met with as the direct result of alcoholism—acute dilatation, fatty degeneration of the myocardium being of frequent occurrence amongst alcoholic patients. My own observations have led me to very much the same conclusions: that there are two sets of conditions which appear to be the direct result of the use of alcohol. I have seen two cases,—both in young, otherwise healthy people, who had succumbed to acute alcoholism,—a condition of acute inflammation of the heart wall without any primary endo- or pericarditis, in which there was marked change in the muscular fibres. In both there was interstitial change, resulting in the accumulation of numerous cells—leucocytes and proliferating fixed connective tissue cells—between the muscle fibres.

In the more chronic alcoholic cases, fatty degeneration of the heart muscle, sometimes of a most marked type, is usually found; but, in addition to this, an increase of fibrous tissue between the bundles of muscle fibres, and in certain cases distinct evidence of wasting of the muscles may be recognised. It is in young alcoholics, and especially in those who have been otherwise healthy, that the study of these changes in the heart should be carried out; as in later life the changes in the blood vessels associated with the kidney and liver and changes in the nervous system, conditions of malnutrition, many of them the direct result of alcoholic poisoning not always directly traceable to this condition, make their appearance.

But the heart appears to be affected by alcohol long before any organic change can be made out in its tissues. For proof of this we must refer to the physiologist, who tells us that alcohol renders systolic output incomplete,² increases the diastolic pressure and causes dilatation of the heart. Dr. Leonard Hill quotes Stephen Hales, who

¹ "Lettsomian Lectures on Disease and Disorders of the Heart and Arteries in Middle and Advanced Life," *Lancet*, London, 1901, vol. i., p. 845.

² Leonard Hill in Schäfer's "Text Book of Physiology," 1900, vol. ii., p. 53.

says: "The heart being in this case like a water mill that is surcharged with a flood both before and behind, its force must needs abate and grow languid." In this condition, experimentally produced on animals by the exhibition of alcohol, the heart may become so large that it can no longer beat in the confined fibrous pericardium, and finally cessation in diastole takes place.

It is interesting to note how many of the newest discoveries in medicine bear either directly or indirectly on the alcohol question.

Quite recently it has been demonstrated that acute rheumatism, or rheumatic fever, as it is called, is the result of the action of bacteria and their poisons, and it has long been known that in rheumatism the heart is one of the organs most frequently damaged. Dr. W. V. Shaw¹ writing on a series of experimental cases, says: "In rheumatism the heart generally suffers as a whole, one part perhaps more in one case, another in another case"; and, again: "In rheumatism the carditis is general." In a series of experiments carried out by him he found that in one case there was a dilatation of the left auricle of the heart, in another that there was acute dilatation of the heart, in a third that the heart itself was dilated and the heart muscle pale and flabby, and in nearly every case examined he found that there was some fatty degeneration of the heart muscle, a condition similar to that met with in acute alcohol-poisoning. It certainly seems rational to assume from all this that, unless we are to accept the theory of homœopathy, we must protest most strongly against the administration of alcohol to patients suffering from acute rheumatic fever, a treatment that savours too much of the treatment with the hair of a dog that is responsible for the bite. I believe that general experience has gone in this direction, but it is well now and again to revise our position, and determine how far pathological facts and experimental observations reinforce the experience of the practical physician.

Dr. H. D. Rolleston, of St. George's, speaking to the North London Medico-Chirurgical Society,² said: "At one time I regarded alcohol as *the* remedy for failing heart in typhoid fever, and considered that it should be given with no niggardly hand in bad cases; but gradually—partly from observation of cases, and partly from the experience of others, especially from a consideration of the facts insisted on by Dr. Graham Steell, that cardiac dilatation is, in the otherwise healthy, frequently due to alcoholic excess—I have come to distrust the value of alcohol in large quantities in typhoid fever. In that disease the myocardium is already suffering from the toxic action of one poison, and would, therefore, be more likely to suffer from the effects of alcohol. I am inclined to rely on other means, and chiefly on the hypodermic action of strychnine."

¹ *Journ. of Path. and Bact.*, Edin. and London, 1903, vol. ix., p. 158.

² See *Med. Temp. Rev.*, 1903, vol. vi., p. 304.

Heart Failure and Alcoholism.

As mentioned above, most physicians and pathologists are in agreement, that cardio-vascular disease—that is, disease of the heart, of the bloodvessels, or of both—is one of the commonest causes of death. Moreover, it is now generally recognised, and in this the physician is backed by the physiologist, that the exhibition of alcohol brings about the dilatation of the smaller bloodvessels, especially those of smallest size, the capillaries—a dilatation which appears to be due to a paralysis of the nerves carrying the stimuli that cause contraction of the small muscles surrounding the bloodvessels. Here, as elsewhere, when there is continuous or intermittent loss of activity of the muscles, resulting from changes in the nerves, there is, along with the diminished activity, an impairment of the nutrition of the muscle, accompanied by some waste, or even degeneration. We are not surprised, therefore, to find that fatty degeneration and calcification of the muscular coat, already described, is very frequently met with in patients who succumb to chronic alcoholism. Moreover, wherever there is marked degeneration of tissue, as the tissues waste, their place is taken by tissues of a lower type—so-called connective tissue or scar tissue. The muscular coat of the vessel forms part only of the vessel wall, but it will be found that wherever it is affected the inner coat, as well as an outer covering of connective tissue, is also, as a rule, considerably altered. Without attempting to give any special account or classification of the changes that take place in the vessels as a result of chronic alcoholism, it may be said that in most cases evidence of its poisonous action may be met with in the bloodvessels, large and small alike.

In old people it is difficult to trace the etiology of these degenerative changes, but in young people who have suffered from chronic alcoholism it is usually fairly easy to demonstrate the connection between cause and effect, and it is my experience that in individual cases in which I have been able to observe certain changes in the walls of the bloodvessels, especially where I have been able to make out some pathological condition in every part of the vessel wall, I have been able to eliminate all causes but chronic alcoholism, of which, therefore, I look upon the thickened vessels in the various organs and tissues of the body (in these comparatively young people) as the direct result. These changes appear to arise in the first place from a proliferation of the connective tissue cells, and, secondly, to result partly from the accumulation of waste products, or even in some cases of tissue *débris* in the tissue spaces, consequent upon which there is an invasion of these spaces by leucocytes or scavenging cells.

Wherever this is marked, there is always a further increase of the large cells that help to form a fibrous or scar tissue. In certain cases these processes proceed slowly and steadily, and at no time does there appear to be any great amount of new cellular tissue formed; there is simply a gradual but continued increase of scar tissue. This increase is almost invariably accompanied or preceded by some form

of degeneration of the special tissues of the organ in which the process is going on. The stages of this process are well illustrated in the changes that take place in inflammation of the liver. First, there is at one extreme an acute inflammation, characterized by dilatation of the bloodvessels, the presence of numerous scavenging cells, and a gradually increasing number of the larger scar-tissue-forming cells, whilst at the other extreme is the chronic alcoholic cirrhosis, the "hobnail" or gin-drinker's liver, in which the scar tissue seems in many cases to be formed almost directly, though on careful examination it will be found that here and there, as in the acute process, there is usually some evidence of the cellular origin of the new tissues, and also of the presence of a number of the scavenging cells—certain indications of the presence of an irritant, and probably also of the accumulation of waste products in the tissues. Moreover, in this condition of gin-drinker's liver, as the scar tissue increases in quantity, so, as in the case of the muscular coat of the bloodvessel, the liver cells waste away and undergo fatty degenerative changes; in some cases they disappear altogether, the fibrous tissue advancing and gradually *replacing* them. Whether this scar-tissue formation goes on in the heart, in the kidneys, in the liver, in the bloodvessels, or in the nerves, the process is essentially the same. It must be associated with the accumulation of poisonous and waste products in the small spaces through which the nutrient fluid passes to the tissues, and must also be associated with marked disturbance of functional activity. Wherever such conditions are present, the changes in structure assume greater or less proportions, according as the organ or tissue in which these changes are met with plays a more or less important part in carrying on the nutrition of the body, or in determining the nervous or muscular activity. Moreover, it must be remembered that in all cases the most highly developed cells are first affected, and that, as these become wasted and degenerated, new tissue—never highly developed, and often of very low type, corresponding to the white scar tissue that one sees in an old wound—comes to take their place; indeed, the contraction of the old scar tissue of a wound has its exact homologue in the contracting scar tissue already described as met with in the liver, in the kidney, and in the brain.

Heart failure is one of the most frequent causes of death in people of adult and advanced years, and anything that predisposes to this heart failure should be studied most carefully. Fatty degeneration is undoubtedly one of such causes of death in people of adult and advanced years, and anything that predisposes to this heart failure must be a most important factor in our death-rate, especially as the patient who suffers from alcoholic fatty degeneration necessarily runs a much greater risk of heart failure during the course of acute fevers, or from overwork, exhaustion, an overfull stomach, and the like. A man with a strong healthy heart pulls through all these, but the man with the weak alcoholic heart succumbs. It is for this reason that insurance companies who surely know their business offer advantages to the total

abstainer such as they cannot afford to offer to the man who is regularly taking alcohol even in small quantities.

It must always be borne in mind that the heart muscle is acting regularly, and with but short intervals of rest. Even under ordinary conditions the heart has an enormous amount of work to get through, and in such an organ it is evident that the whole of the nutrient processes, whether of bringing up and utilising fresh nutrient substances, or of throwing out waste and used up material, should be kept in as perfect a condition as possible ; and it appears to be inevitable that if either the taking in or throwing out powers of these tissues are in any way interfered with, there must be a loss of that margin of reserve possessed by the healthy heart—a reserve which must give out sooner or later according to the drafts made upon it. A man may have lived only fifty years, but his heart and blood vessels may bear the marks and scars usually found only after seventy or eighty.

Changes in the Bloodvessels.

In the vascular system, by which the blood is conveyed to various parts of the body, the changes produced by large quantities of alcohol are, as a rule, scarcely recognised, being overshadowed by the more marked changes that take place in the other tissues of the heart, the liver, and the brain. Nevertheless, on careful examination of the delicate lining of the blood vessels and of the spaces that surround these blood vessels, fairly pronounced evidence of the poisonous action of alcohol on these tissues may be demonstrated. Their nutrition has been interfered with, and rapidly-produced degenerative changes are in evidence.

In chronic alcoholism, in which the poison is acting continuously and over a long period, a peculiar fibrous condition of the vessels is induced, apparently the result of a slight irritant action on the tissues of which the walls of these vessels are made up. The wall of the vessel may become thickened throughout its whole extent, or irregularly, and the little bundles of muscles begin to waste away as the new fibrous or scar-like tissue is formed. This muscle may undergo fatty degeneration and calcification, and the so-called “pipe-stem” vessels, rigid and brittle, which give way readily before any great pressure of blood result.

If the rupture takes place in the vessels of the brain, paralysis or death rapidly ensues. Vessels thus affected cannot bring up a sufficient quantity of blood to the organ which, under normal conditions, they should supply, and the change is so far-reaching that even the smaller vessels, through the walls of which the nutrient materials make their way out from, and certain of the waste products make their way into, the circulating blood, are so far altered that their walls constitute a barrier to the proper transmission of nutrient and waste materials, with the result that the nutrition of the surrounding tissue is materially interfered with.

Another condition in the bloodvessels specially associated with alcoholism is that peculiar rigidity of the medium-sized bloodvessels

which results from a degeneration of the little muscles, so arranged in the wall of the vessel that they form a kind of hollow cylinder. In certain alcoholics these muscles appear to undergo a fatty change similar to that met with in the heart muscle. Here, however, as in the fibrous condition, the fatty degeneration is followed by a curious deposition of lime salts in the altered tissue, so that the vessel, in place of being an elastic and contractile tube, comes to be a rigid tube almost like the pipe-stem form described above. It does not dilate to allow of the ready flow of blood, nor does it contract to drive it on. A very much greater amount of work is thus thrown upon the heart, which now has to drive the blood through a vessel from which it gets no assistance in the form of either muscular or elastic contraction, with the result that, having more work to do, the heart becomes hypertrophied or overgrown, a further amount of its reserve power and energy is used up, and this vital organ is brought still nearer the marginal line between safety and failure. Calcification or deposition of lime in the vessels has long been recognised as a sequel to fatty degeneration. It occurs in patients who, though not necessarily drunkards, either intermittent or habitual, nevertheless, up to the later years of adult life or the earlier period of old age, have taken what are called moderate quantities of alcohol. This form of vascular disease, at one time scarcely associated with chronic alcoholism, is now supposed by some of our foremost physicians to be somewhat intimately associated with slight but long-continued alcoholism. My late friend Robert Irvine and I,¹ in some experiments on the deposition of carbonate of lime in living and dead tissues, found that this substance is very readily and regularly deposited from alkaline blood, and from blood that contains a high proportion of carbonic acid. Both of these conditions are present in the blood of animals that have received even small doses of alcohol. There is some evidence that in human beings who take alcohol similar conditions obtain, and we may accept it that this process of calcification, through which the vessels become more brittle and less distensile, is, in many cases, a direct result of the conditions induced in the blood and tissues by alcohol, not necessarily in very large doses, but acting uninterruptedly over a long period.

Changes Induced in the Brain by Alcohol.

Of the changes that take place in the brain as the result of the administration of alcohol, our knowledge would be very limited had it been necessary to confine our attention to the human tissues, so many sources of error, both in observation and interpretation, here being possible. Fortunately, however, we are not without definite evidence on this point, as Dehio,² Colin C. Stewart,³ and Berkley⁴ have all

¹ *Proc. Roy. Soc. Edin.*, 1889, vol. xvi., pp. 324-354.

² *Centralbl. f. Nervenhe. u. Psychiat.*, Coblenz u. Leipzig, 1895, N.F., Bd. vi., S. 113.

³ *Journ. Exper. Med.*, N.Y., 1896, vol. i., p. 623.

⁴ *Johns Hopkins Hosp. Rep.*, Baltimore, 1897, vol. vi., pp. 1-108, 15 plates; and *Brain*, London, 1895, vol. xviii., pp. 473-496, 5 plates.

carried out experiments on acute alcoholism in the lower animals. They all noticed marked degenerative changes in the lining membrane of the small vessels of the brain, whilst in the spaces surrounding the vessels Berkley found what he calls an exaggerated condition of waste, a "clogging" due to the accumulation of rapidly produced waste products. Before, then, we come to the nerve cells, the proper cells of the brain, we must see what changes occur in the vessel walls and in the spaces surrounding them. In some cases small clots are formed in the vessels—clots which interfere with the transmission of blood along the normal channels. This clogging of the vessels and of the spaces around affords evidence of a very active breaking down of the tissues, but it is still more important as a cause of continued interference with the nutrition of the surrounding tissues, thus playing a part in the determination of further degeneration and breaking-down.

The Value of New Methods in the Study of Alcoholism.

Modern scientific physicians have the great advantage over their brethren of earlier date in that by the use of new methods they can detect minute changes in diseased organs and tissues that at one time were undemonstrable. They are able to associate cause and effect in the development of disease in a way hitherto undreamed of, and to determine—in some degree, at any rate—the conditions under which disease is produced, the weak points in the patient that predispose to the disease, the special surroundings of the patient that contribute to this weakening of the tissues, and the special factors that are to be considered the actual or exciting causes of disease. Although it has been found, for example, that the tubercle bacillus is the exciting cause of consumption, and that the cholera bacillus has a similar association with Asiatic cholera, it has also been found that certain people are extremely resistant to the invasion of these organisms; that one man may swallow the cholera bacillus and be unaffected, whilst his neighbour, swallowing a tenth part of the dose of the same bacillus, may succumb to a severe attack of cholera; and that, although one patient may inhale the tubercle bacillus with impunity, his neighbour succumbs almost at once to the attack of this organism. It has been observed, also, that the conditions under which these bacilli exist outside the body, the soil into which they fall, the air and light to which they are exposed, all have a material influence in determining the multiplication and growth, or the degeneration and death, of these organisms. By various methods it has been demonstrated how these bacilli act, how they invade the body, what they do, and what changes they produce when they get there. We may say, indeed, that we are gradually obtaining a more complete and accurate knowledge of the natural history of disease. What applies in the case of these specific poison-producing and death-dealing organisms applies also, in a less degree, perhaps, in the case of alcohol. The tissue

changes induced by acute alcohol-poisoning are, of course, much more readily recognised, and their relation to their causal factor determined, than are the changes produced in chronic alcohol-poisoning. Exactly the same distinction is observable in the popular mind in regard to typhoid fever and tuberculosis. Typhoid fever, with its short latent period of incubation (that is, the time between the actual infection and the period at which the disease manifests itself), is, by the man in the street, far more readily recognised as an infective disease than is tuberculosis, in which the disease manifests itself at a much later period after the actual infection has taken place; and although many earlier observers had contended very strongly that tuberculosis was an infective disease, it was not until comparatively recently that the theory of infection in tuberculosis was accepted, even by medical men. Similarly, not only physicians, but the general public, have long recognised acute alcoholism as a toxic condition, but only in quite recent times have many physicians and a select few of the laity appreciated what an important part chronic alcoholism plays in diminishing the resistance of the tissues to the invasion and action of disease-producing organisms; how alcohol acts along with the poisons produced by these infective organisms, or alone in setting up a series of changes which in themselves constitute a damage corresponding in many of its more important features to that induced by what we call disease. Ordinary poisons and disease-inducing organisms and their poisons can now, indeed, be studied in a way that, at one time, was impossible.

Action of Alcohol on the Brain Cells.

Under the action of considerable doses of alcohol, just as under the action of large doses of diphtheria toxin, remarkably definite and readily recognisable changes may be demonstrated in the nerve cells of both man and the lower animals, especially those near the plugged vessels and lymph spaces already referred to. The nerve cell first loses the peculiar mottled appearance that it has when stained with certain reagents, and then swells up. In the small branches that are given off from the long processes leading out from these cells very characteristic alterations may be seen—alterations indicating that profound modifications have taken place in them as the result of the action of the poison. They are never met with in the healthy human brain, nor are they found in the brains of healthy animals.

As has already been stated, chronic alcoholism has hitherto largely escaped recognition, except in cases where the symptoms of the disease have been exceedingly well marked. So definitely is this the case, that amongst physicians generally there has always been a proneness to ascribe a causal connection between chronic alcoholism and disease only as a last resort. Now, however, that it is possible to study the condition experimentally in animals, to examine the tissues of animals in which chronic alcoholism has been induced, and to compare these with the conditions met with in the human subject, chronic

alcoholism has come to be accepted as a far more important factor in disease than was at one time dreamed of. In asylums, in workhouses, and similar institutions, physicians have, of course, long recognised changes in the organs and tissues that were invariably associated with chronic alcoholism. Special brain cells were found to be shrunken and atrophied, their processes—connecting-links, as they may be called—were stunted, the structure of the cell was altered, little cavities were found in its substance, and pigment was deposited in it. Such changes, no doubt, occur also in the brain in which there is evidence of impaired nutrition, or in the late stages of certain diseases; but as they occur also in cases of chronic alcohol-poisoning, we gather that the changes in the nerve cells in chronic alcoholism are those of imperfect nutrition, perhaps the result of a special form of poisoning.

Running out from the normal nerve cell is a series of long processes, on which are arranged numerous delicate lateral twigs. The long processes taper off slightly and regularly from the base for a short distance, after which they are prolonged as threads of fairly equal size throughout the remainder of their length. In chronic alcohol-poisoning where the body of the nerve cell is altered, and even in some cases where no very marked alteration can be made out, these long processes are seen to undergo remarkable changes. Instead of being of nearly equal thickness throughout, little swellings make their appearance at regular intervals, first near the tip of the process, and gradually working back towards the body of the cell, so that after a time the process has almost the appearance of a string of beads. Whilst this is going on the fine lateral twigs are also altered, some of them becoming swollen and shortened, others disappearing entirely: ultimately the bulk of them may so disappear.

Let us see what this means. The cell may be looked upon as a small electric battery, the long processes leading off from it as wires, whilst the smallest twigs may be looked upon as little associating wires, taking the place of induction coils, bringing the various processes into association with one another, and passing on the currents, as it were, from cell to cell in definite directions. Whenever there is irregular thickening and shortening of the long fibres and disappearance or stunting of the small lateral twigs, certain of the communications between cell and cell are done away with; so many of the connecting wires are cut out, as it were, and the interference with the passage of nerve currents along the nerves is so great that, beginning with the more delicate processes of thought and going on to the machinery by which we move or live, the nervous mechanism is gradually thrown out of gear. Berkley points out that the conditions found in the brain of a slowly alcoholised rabbit are also to be met with in the brain of the man who has suffered from chronic alcohol-poisoning, in all cases, and that they vary in degree only, the resemblance in some instances being more, in others less, marked. These changes are not, he says, "peculiar to the effect of alcohol, they may be reproduced by any irritant drug or bacterial toxic product circulating in the blood and acting for a

considerable time on the living protoplasm of the nerve cell"; and, again: "Alcohol, which was supposed to be the least deleterious of all the series, has a very definite and destructive effect upon the nerve cells."

Action of Alcohol on the Nerve Fibres.

As I have pointed out elsewhere,¹ there was at one time, before the minute structure of the brain had been carefully studied, and, consequently, before the evidences of disease that are found in the nerve cells of the brain had been recognised, a certain danger that the importance of the alterations in the nerve fibres in cases of alcoholism might be over estimated. The paralysis and other alcoholic nervous symptoms were, in most cases, ascribed almost entirely to changes in the peripheral nerves. Now, however, that marked pathological changes have been demonstrated in the nerve cells, there appears to be a danger that we may go to the opposite extreme, and discount the poisonous action of alcohol on these nerve fibres. Just as diphtheria toxin acts both upon the nerve cells and the nerve fibres (Sidney Martin),² so alcohol exerts its poisonous action on both these sets of tissues.

Any account of the pathological changes induced in the nerve fibres, would, I am afraid, be far too technical for any but a medical audience, but I may say that if you look upon the nerve as an electric wire or core with an outer or insulating covering you may follow my description. First of all, in these toxic conditions the outer covering breaks down; then, after a time, the central core, corresponding to the wire—the axis cylinder, as it is called—becomes irregularly thickened and thinned, so that, instead of a solid rod of equal thickness, we have something almost like a string of beads. Wherever this irregular thickening is produced, the impulses are irregularly transmitted along the nerves, and the patient finds that his experience is no longer to be relied on; he is thoroughly at fault, he is unable to translate the sensations transmitted by these altered nerves, and he is unable to keep his various muscles under control simply because his experience no longer informs him what force he should send along a certain nerve in order to bring about the required stimulation of a muscle or group of muscles. In addition to these changes in the actual nerve fibres, there is, in alcoholic poisoning, an increase in the amount of fibrous tissue formed between them, just as there is around the small vessels of the liver and certain other organs.

The Cumulative Action of Alcohol.

It must be noted that the above changes in the nerve usually come on suddenly, and in many cases appear to result from the action of

¹ "The Pathology of Alcoholism," *Med. Temp. Rev.*, 1903, vol. vi., p. 81.

² *Suppl. Loc. Govt. Bd. Rept.*, London, 1902-3, p. 427, and "Goulstonian Lectures on the Chemical Pathology of Diphtheria," *Brit. Med. Journ.* London, 1892, vol. i., pp. 641, 696, 755.

the poisons manufactured during the course of certain diseases ; but it is now generally accepted that these poisons act far more certainly, more rapidly, and more intensely, where alcohol has been quietly working away for some time before the advent of the second poison. Dr. Alexander James¹ has drawn special attention to this fact. Arguing from a series of observations on cases of inflammation of the nerves, he came to the conclusion that in most cases alcohol had been exerting an injurious action long before the onset of the inflammation of the nerves, of which the special symptoms are the manifestation. He reports a definite case in which alcoholic-poisoning had previously helped to cause the development of heart damage, and others in which disease of the stomach, liver, or kidneys, had been brought about by alcohol before the inflammation of the nerves has shown itself. These inflammations, then, are to be looked upon as an addition to the other evil effects of alcohol. A parallel case is the delirium tremens so apt to supervene in alcoholic patients suffering from acute diseases, such as pneumonia or typhoid fever, but seldom or never met with in non-alcoholics.

The Action of Alcohol in the Specific Fevers.

So far we have examined the action of alcohol principally in relation to what we may call normal tissues. Let us now consider an aspect of the subject which, from a popular no less than from a medical point of view, is of great interest. I had my attention first drawn to it by my "old chief," Dr. Muirhead, a distinguished and much valued Edinburgh physician, who in my time held (and probably still holds) very definite opinions as to the importance of avoiding the use of alcohol, except for very specific purposes, in the treatment of cases of pneumonia. This, following immediately on the advice given by Dr. Wyllie, now Professor of the Practice of Physic in the University of Edinburgh, that in no case of delirium tremens should alcohol be given, led me to ponder whether there was not some association between the two sets of conditions, both of which required the same treatment. At that time nothing was known of the pneumococcus and its relation to pneumonia, though pneumonia has now long been recognised as an infective disease ; but I came to the conclusion that in both conditions there must be some poisonous substance or substances that had to be got rid of before the patient could recover, and that alcohol in some way or other interfered with the excretion of these substances. Further, I had the idea that alcohol in itself might assist the action of these poisonous products—that, in fact, we must have a cumulative action of alcohol and these poisons, whether they were simply the result of metabolism of the tissues or of some reaction between the primary cause of the disease and the tissues themselves. Lastly, I came to the conclusion that alcohol itself might act specially on the nerve tissues, irritating or paralysing them,

¹ *Ed. Med. Journ.*, 1896.

as the case might be, and giving rise to certain symptoms associated with the two diseases. The theories were crude enough, and some of them I now see would not hold water; nevertheless, the practice was thoroughly sound, for, as Dr. Muirhead pointed out, the death of a case of pneumonia uncomplicated by alcoholism was of the rarest occurrence—in fact, at that time I seldom saw one. Since then I have had reason to modify my opinion, but only in the case of the pneumonias that follow influenza, in which the influenza poison appears to play much the same part that alcohol plays in the cumulative poisoning.

Alcohol and Tuberculosis.

It is extraordinary to find what a great change has taken place in the opinion of medical men as regards alcohol and tuberculosis. It may be said that Professor Brouardel's statement to the London Congress on Tuberculosis,¹ held in 1902, was not backed by many figures, but we may take it that it was meant to be a popular exposition of what almost every author, writing in recent years on pulmonary tuberculosis, has put prominently forward, that alcoholism is the most active co-operator that the deadly tubercle bacillus or germ of tuberculosis has. Professor Osler,² Dr. West,³ Dr. Howship Dickinson,⁴ M. Legrain,⁵ and many others all insist that alcohol, far from being antagonistic to tuberculous disease, as was at one time supposed, is one of the great predisposing causes to both acute and pulmonary tuberculosis. It is recognised that this disease is in alcoholic patients far more likely to assume an acute form, for, as Dr. Dickinson says, "we may conclude, and that confidently, that alcohol promotes tubercle, not because it begets the bacilli, but because it impairs the tissues, and makes them ready to yield to the attack of the parasites."

Dr. Newsholme,⁶ discussing a paper by Dr. Mahaim of Lausanne points out that the alcohol question is an important one, not only for social reasons, but also because alcohol is a determining factor in increasing the mortality from tuberculosis. In France the districts in which the greatest amount of alcohol is consumed have the highest mortality from tuberculosis, alcohol apparently acting as a devitalising agent, and rendering the person indulging in it to excess a more easy subject of infection. It is interesting to note in this connection that Baudron of Paris in 1901 showed that a consumption of alcohol of

¹ *Trans. Brit. Congress on Tuberculosis*, London, 1902, vol. i., pp. 48, 63.

² "The Principles and Practice of Medicine." Fourth Edition, 1901.

³ "The Diseases of the Organs of Respiration," London, 1902.

⁴ The Baillie Lecture on "The Seed and the Soil," *Lancet*, London, 1902, vol. i., p. 299.

⁵ *Bericht ü. d. ix. Internat. Kongress gegen d. Alkoholismus abgeh. in Bremen*, 1903, Jena, 1904, S. 55; Abstract in *Med. Temp. Rev.*, 1903, vol. vi., p. 221.

⁶ Thirteenth Internat. Congress on Hygiene and Demography, held at Brussels in 1903, cf. *Med. Temp. Rev.*, vol. vi., p. 313.

12·5 litres per person corresponded to a mortality from tuberculosis of 32·8 per 1,000, whilst a consumption of 35·4 litres of alcohol per person corresponded to a death-rate from tuberculosis of 107·8 per 1,000. Dr. Niven maintains, and the fact is obvious when pointed out, that not only are alcoholics debilitated by drinking, but, frequenting ill-ventilated public-houses, they are infected by those who are already tuberculous who usually indulge in indiscriminate expectoration.

Alcohol and Predisposition to Disease.

Elsewhere¹ I have brought together some account of the effect that alcohol has in inducing a predisposition to the attacks of certain diseases. In Shanghai, McLeod and Milles² insist that cholera is exceedingly rare amongst the European section of the population, but amongst sailors who have indulged in alcoholic excess it is of more frequent occurrence, and then in a very fatal form. Alcoholism, according to these observers, then, is an important factor in increasing the susceptibility to Asiatic cholera.

Abbott's Experiments on Suppuration.

A. C. Abbott, under the auspices of "the American Committee of Fifty to Investigate the Alcohol Question,"³ made a series of observations on the action of alcohol in predisposing animals to the infection produced by certain pus-producing organisms. He found that the normal resistance of rabbits to these organisms is greatly diminished by the use of alcohol when given daily to the stage of acute intoxication. He found, indeed, that not only was pus more readily formed and at an earlier date, but it was formed in larger quantities, and that an animal to which alcohol was given succumbed much more readily than did a non-alcoholised animal. The experience of surgeons such as Pearce Gould,⁴ Victor Horsley, and of others with whom I have discussed this question, affords confirmation of these experiments; indeed, it is a well-recognised fact that operations on alcoholic patients are dreaded by all surgeons, whatever may be their opinion on the general question of total abstinence.

It will be within the recollection of some of those present to-night that at one time alcohol was looked upon almost as a "specific" in the treatment of what are now called the infective fevers. That, however, is now an old story, for some years ago there was a great revulsion against the alcohol treatment of typhoid fever, of inflammation of the lungs, and of similar conditions, and it was recognised that not only could patients recover from these diseases when alcohol was not prescribed, but that they actually did better without it.

¹ *Med. Temp. Rev.*, London, 1903, vol. vi., pp. 4, 36, 73, 105.

² *Proc. Roy. Soc. Edtn.*, vol. xvi., p. 18; *Rep. Lab. Coll. Phy. Edin.*, 1889, vol. i., p. 161.

³ *Journ. Exper. Med.*, N.Y., 1896, vol. i., p. 458. See also full Report of this Committee.

⁴ *The Practitioner*, London, November, 1902 (Special Alcohol Number).

Experiments on Animals—Immunity.

Recent bacteriological research has enabled us to throw a clear light on alcoholism in relation to the specific infective diseases. Numerous workers, following up the lead given by Abbott, have accumulated much evidence that alcoholised patients and animals are more readily attacked by the various febrile diseases—inflammation of the lungs, erysipelas, typhoid and other fevers—than are those not alcoholised.

Delearde's Experiments.

Dr. Deléarde's¹ experiments have been very frequently quoted, but they are so important that I do not apologise for again bringing them forward. This observer wished to determine whether and how alcohol weakens the resisting powers of the body, and, if it does, what are the factors by which any such weakening may be brought about.

Many of you are aware that it is possible to protect animals against severe attacks of certain diseases by the production in them of mild attacks of the same diseases. A child that has suffered from scarlet fever seldom contracts that disease a second time; again, a patient who has had small-pox or typhoid fever is usually immune against a second attack. For his experiments Deléarde selected three diseases—rabies or hydrophobia, tetanus or lockjaw, and anthrax or splenic fever of cattle. In tetanus and anthrax the specific micro-organism producing the disease has been described in each case, and in all three cases a diminished susceptibility or artificial immunity has been induced. All three diseases may be induced in acute and fatal form, or, if the virus be weakened by special methods, a milder attack, which under ordinary circumstances protects the animals against more severe attacks of the disease, may be produced.

Hydrophobia or Rabies and Alcohol.

Using rabbits, he gave to each of a certain number of them a quantity of alcohol, commencing with about $1\frac{1}{2}$ drachms, and gradually increasing the dose to $2\frac{3}{4}$ drachms a day. This quantity of alcohol undoubtedly interfered with the nutrition of the rabbits, as its administration was followed by "slight falling off of weight: but after a time this fall ceased, and then the animal gradually got to its normal weight." It accommodated itself to the new conditions, as it were; but although it was restored to its normal weight, very marked changes had taken place in its body fluids and tissues. Having prepared his alcoholised animals, several non-alcoholised animals were "vaccinated" against hydrophobia. After they had acquired a considerable degree of immunity—that is, when they were no longer very susceptible to the hydrophobia poison—alcohol was administered to them as above. They were then injected with what, under ordinary circumstances, would be a fatal dose of the hydrophobia poison. All the animals remained alive. The tissue had become less susceptible owing to the

¹ *Ann. de l'Inst. Pasteur*, Paris, 1897, t. xi., p. 837.

vaccination, and so firmly rooted was this diminished susceptibility that alcohol was not able to interfere with it. The animal remained immune.

He then carried out a second series of experiments, the procedure for the production of immunity being carried out as before, with this difference, that whilst it was going on the animal received alcohol in the quantities mentioned above. Here the result was most unexpected and startling. No immunity was produced; the animal remained just as susceptible to the disease as if no attempt had been made to vaccinate it. The alcohol so interfered with the reaction between the vaccine and the tissues that no immunity was produced. Carrying the experiment a step further, he took one of the animals to which he had been giving alcohol for some time, and, discontinuing the alcohol, he, after a few days, vaccinated the rabbit with hydrophobia virus. He found that a certain degree of protection was conferred, but it was not so marked as in the case where no alcohol had been given at any stage. These experiments satisfied him that acute alcoholism has the effect of preventing the acquisition of a condition of immunity. The effect of alcohol on the tissue cells is not so marked, however, that when its administration is stopped they cannot regain some of their original powers and properties. Further, when the property of immunity has been acquired before alcohol is given, the cells retain this property even in the presence of considerable quantities of alcohol.

Deléarde points out that clinical experience bears out these experiments. Indeed, his attention was first directed to this subject by observations on an alcoholic patient bitten by a mad dog. This patient appeared to be much more susceptible to the action of hydrophobia poison than a second patient bitten and inoculated under otherwise much less favourable conditions. The first case was that of a man of thirty years of age, of intemperate habits, who was bitten on the hand. Though subjected to a careful and complete antirabic treatment, he succumbed. The other case was that of a child, aged thirteen years, who, on the same day, was bitten on the face by the same dog. The course of antirabic treatment was exactly the same, but here, although the bite was more severe and its position more dangerous—the head and face being the most dangerous positions in which a patient can be bitten—the child recovered. In comparing these two cases, the only factor that seemed to be more unfavourable in the case of the man than in that of the child was the intemperate habits of the former, who took alcohol even during the period of treatment. Deléarde was so strongly impressed with what he saw in the wards and in his experiments that he strongly advises patients who have been bitten by mad dogs to abstain from the use of alcohol, not only during the period of treatment, which is carried out for the purpose of producing an active immunity against the hydrophobia poison, but also for a period of at least eight months afterwards, during which time there appears to be a steady and persistent increase of immunity.

Alcohol and Lockjaw or Tetanus.

In the case of lockjaw, however, alcohol exerts a much more serious effect, for animals that have been vaccinated against lockjaw, when alcoholised, lose their insusceptibility to the disease, and may be readily infected, in this differing markedly from animals vaccinated against hydrophobia. Rabbits vaccinated against lockjaw and simultaneously alcoholised do not acquire immunity at all readily; under these conditions it is very difficult indeed to protect them against the lockjaw poison. Here, however, as in the case of hydrophobia, animals first alcoholised and then vaccinated against lockjaw may acquire an insusceptibility to the lockjaw if the alcohol be stopped as soon as, or before, the process of vaccination is begun. It is evident from these experiments that even after immunity has been acquired alcohol may destroy it, a fact which should be remembered in connection with treatment. Whenever a patient is recovering from an attack of one of the specific infective diseases, he recovers, because, during the course of the disease, he has acquired a certain specific immunity, the result of changes in the tissues and fluids of the body. If alcohol impairs this immunity in any way, or interferes with its production, the patient's chance of recovery must necessarily be diminished.

Alcohol and Anthrax or Splenic Fever.

Continuing his experiments, Deléarde found that it was almost impossible to confer immunity against anthrax on animals that were alcoholised during the period that they were being vaccinated, and although animals first alcoholised for a period and then vaccinated—the alcohol being stopped during the period of vaccination, as in the case of hydrophobia and lockjaw—acquire a certain degree of immunity, they rapidly lose condition when infected. They certainly suffer more severely than do the non-alcoholised animals vaccinated at the same time and infected in the same manner.

**EFFECTS OF ALCOHOL GIVEN BEFORE (AND
THEN STOPPED), DURING, AND AFTER THE
“PROCESS OF IMMUNISATION.”**

	BEFORE.	DURING.	AFTER.
RABIES ...	+	—	+
LOCKJAW ..	+	—	—
ANTHRAX..	+	—	+
	—		—

NOTE. + = Production of good immunity.

+ = ,, ,, slight ,,

— = ,, ,, no ,,

Laitinen's Experiments.

Most remarkable experiments are those of Laitinen of Helsingfors,¹ carried out in Professor Fraenkel's pathological laboratory at Halle, and in great part supervised and controlled, or at any rate observed, by the Professor. They are perhaps of even greater importance than are those already quoted, from the fact that much smaller doses of alcohol were used than in either Abbott's or Deléarde's experiments. The dose for each animal was calculated and based on the amount given as a nutrient substance, as a medicine, or both, in a well-known sanatorium at Davos. This worked out at from 4 to 6 drops to every pound weight of the rabbit used. Laitinen was careful to keep well within this quantity, and to use the alcohol in a well-diluted form. It was given over long periods—weeks or even months before the final stage of each experiment was entered upon—and its use was continued for some time afterwards. He also performed a series of experiments on animals to which the doses of alcohol were large enough to produce acute alcohol-poisoning.

Into animals so prepared he introduced the bacilli of splenic fever, tubercle bacilli—the bacilli of consumption—and the poison produced by the diphtheria bacillus. The dose of the virus or poison was in each case very carefully measured, both as regards virulence, number of bacilli, and quantity of poison. As the result of numerous experiments, he was convinced that alcohol, whether introduced subcutaneously or by the stomach, induces in the animal body an increased susceptibility to infection by the organisms with which he worked, or to poisoning by their toxins.

Practical Conclusions.

Abbott, Deléarde, and Laitinen, supported by Fraenkel, Calmette, Pearce Gould, and others, draw the practical conclusion that physicians and surgeons often commit a grave error in administering even comparatively small doses of alcohol to patients suffering from the special diseases with the viruses of which these various experiments

FEVER STATISTICS.

CASES TREATED BY DR. J. J. RIDGE WITHOUT ALCOHOL.

Cases.	Deaths.	Mortality.
SCARLATINA.		
2331.	44*	1·88 per cent.
DIPHTHERIA.		
258.	31.	12 per cent.
ENTERIC FEVER.		
159.	27.	17 per cent.

*All deaths from Intercurrent Diseases included.

¹ *Acta Soc. Sc. Fennica*, 1890, Helsingfors, 1900, t. xxix., No. 7.

ISOLATION HOSPITAL.

(DR. WARNER, OF LEICESTER.)

FATALITY RATE FOR 1902.

Scarlatina	...	...	...	1·7 per cent.
Diphtheria	...	...	...	5·6 „
Enteric Fever	...	...	...	8·1 „
Small Pox	...	...	...	7·0 „

No alcohol given in any of the above cases.

were made. It is also agreed that in certain other infectious diseases—such as pneumonia—or intoxications—such as that produced by a snake-bite—the use of alcohol is not merely useless, but often actually harmful.

Suggested Explanations.

Some of the earlier, and even some later, observers were of opinion that the diminished resistance noted in the above experiments must be the outcome of abnormal conditions in the various organs—alimentary canal, liver, kidneys, heart, nervous system, etc.—or that it might be due to a kind of starvation, in which condition animals are undoubtedly more susceptible to the attacks of infective fevers. This explanation, however, though accounting for some of the phenomena observed, is not sufficient to account for all.

Action of Phagocytes or Devouring White Blood Corpuscles.

In pneumonia and snake-bite, when recovery takes place, there is an increase in the number of leucocytes or white blood corpuscles in the part affected; this increase appears to be a necessary factor in the cure of the patient.

Deléarde insists that it is essential to recovery from any of the microbic infections or intoxications, that the integrity of the leucocytes should be carefully maintained. In the presence of alcohol, just as in the case of opium-poisoning—as pointed out by Metchnikoff and his pupils—this integrity is not maintained. Two Belgian observers, Massart and Bordet,¹ in carrying out experiments on the attraction and repulsion of the living leucocytes by various bodies, found that alcohol, even in very dilute solution, strongly repels leucocytes, driving them away from its neighbourhood. If, then, we have alcohol circulating in the blood, even in very minute quantities, the leucocytes cannot make their way into the blood at all readily, and therefore cannot be carried from place to place. Alcohol thus prevents the white cells or leucocytes from coming up to attack invading organisms; it also assists other poisonous substances that, in more or less concentrated form, have the power of repelling leucocytes, the two

¹ *Journ. de Med., de Chirurg. et de Pharmac.*, Bruxelles, 20 février, 1900: *Ann. de l'Inst. Pasteur*, Paris, 1891, t. v., p. 417.

substances acting cumulatively, and driving away, or in certain cases paralysing, these white cells of the blood. The importance of this may be gathered from the fact that the leucocytes appear to act as a kind of sanitary police force. They make their appearance wherever dead matter is to be removed; they attempt to prevent the invasion of the body by disease-producing organisms, and once they come to grips with their opponents, they die rather than give way. They may be said to consider their work so important, however, that if their opponents are too strong they often attempt to keep out of their way for a time until such opponents are weakened, or they themselves have had time to prepare themselves for the fight. The disease-producing organisms, get into the tissue of animals and patients during the time that alcohol is holding back the leucocytes, and meeting with no resistance from them, they set up a severe attack of the disease; the organisms obtain such a foothold that the leucocytes are never able to drive them out.

In all diseases, then, in which leucocytes help to repel or remove the invading organisms, or in which they retain their power of reacting to, or of carrying on their functions, in the presence of toxins, we should expect that alcohol would deprive them of some of this power, or interfere with the acquisition by these cells of a greater resisting power. Alcohol, then, in the first place, interferes with the reactions of the cells to poison, thus interfering with the production of immunity; beyond this, however, it reinforces the poison formed by the disease-producing organisms, often with results most disastrous to the patient,

Alcohol Lowers Nutrition and Depresses the Temperature.

Another factor in this action of alcohol in increasing the susceptibility to disease is undoubtedly its power of interfering with nutrition, especially of young, unstable, or highly-organised tissues—its action on young children and young animals, unborn or born, is now fully recognised. It also lowers the temperature, especially when given in what may be called poisonous doses. When large doses of alcohol are given, the temperature is lowered beyond the normal, and during this temporary lowering of temperature the body seems to be specially susceptible to the attacks of infective agents. Pembrey,¹ one of the authorities on this subject, has pointed out that the fall in temperature is due to increased vascularity of the skin and increased activity of the sweat glands, the normal reaction to cold being paralysed by large doses of alcohol.

Most authorities agree that alcohol taken in small quantities causes only a slight lowering of temperature—less than half a degree; but when considerable—that is, poisonous—doses are given the effect is much more marked. The lowest temperatures recorded during life are observed in drunken persons. The temperature of a normal rabbit

¹ In Schäfer's "Text-book of Physiology," Edin. and London 1900, vol. ii., p. 53.

exposed to intense cold falls only about 5°F. , whilst the temperature of an alcoholised rabbit may fall as much as 34°F. Similarly, the fall in temperature of a normal guinea-pig exposed to cold is only from 0.2° to 0.36°F. ; of an alcoholised guinea-pig exposed in the same way the fall may be as great as 18°F. Pasteur found that, by placing a hen with its feet in cold water, and thus lowering its temperature, he could render it susceptible to anthrax, though up to that period those who had worked with this disease had been unable to produce anthrax in the hen. Similar observations have since been made by other observers.

Alterations in the Fluids of the Blood.

We must, however, look beyond this factor of temperature in our search for predisposing causes. Not only the cells of the body, but the fluid in which these cells are carried, and which give material to and receive waste or other excreted products from them, play an important part in resisting disease. It has been demonstrated by Ehrlich, Myers,¹ and others that the introduction of certain substances into the body modifies its fluids in a most remarkable manner. For example, if egg albumen be introduced into the abdominal cavity of the rabbit, it is taken into the blood, and in the process of assimilation by the body it appears to affect the cells in such a fashion that they secrete something into the blood that, added to egg albumen in solution outside the body, brings about its precipitation.

Uhlenhuth,² extending the scope of these experiments, found that the blood serum from an animal—ox, sheep, etc.—when introduced into a rabbit brought about the production of some substance in the blood of that rabbit that, when added to the blood serum with which the rabbit was first injected, threw down a precipitate which could be readily measured. Nuttall³ confirmed and further extended these observations and found that it was possible to distinguish the blood of different species of animals—human blood from cow's blood, dog's blood from sheep's blood, and so on. Further, when the red blood corpuscles of one animal are introduced into the abdominal cavity of another species, it is found that if a drop of blood be taken from the ear of the second animal and added to the blood of the first there is a breaking-down of the red blood corpuscles in the first blood. Alcohol appears in some cases to interfere with certain of these processes connected with the breaking-down of blood (haemolytic processes) in others to accelerate them. As in the case of the production of immunity, so in the case of haemolysis or breaking-down of the blood, the presence of alcohol interferes with the ordinary physiological processes with the result that certain of the phenomena that appear when no alcohol is given cannot make their appearance when it is administered.

¹ *Lancet*, London, 1900, vol. ii., p. 98.

² *Deutsche med. Wochenschr.*, Leipzig, 1901, Jahrg. xxvii., S. 82.

³ *Journ. of Hyg.*, Cambridge, 1901, vol. i., p. 367.

In each cell in our body we have, according to Ehrlich,¹ a central group of molecules, sometimes a very complicated one, around which are arranged a series of affinities, links or hooks—receptors, or side chains as they are called. To these hooks other albuminoid groups are attached, and it is through the hooking-on of these albuminoid groups that the cell is nourished; without them it could not link on to itself the material that it requires for its nutrition. These receptors or hooks have a special affinity for other albuminoid molecules, which, however, have to be linked on in a special fashion. Certain molecules acting as anchoring chains have one form of link at one end and another kind of link at the other, one form holding to the cell the other attaching the molecule to be absorbed; without this intervening and accommodating link the two could never be connected. This connecting chain is spoken of as a fixative, and it is a curious fact that such a kind of link is always met with in the blood. It is very stable, and is not destroyed by high temperatures. At the outer end of this fixative, and hooked on to it, as it were, are certain groups of atoms which appear to be derived from living cells. They have certain characteristics similar to those met with in the “ferments,” and they are destroyed at a temperature of from 50° to 55° C. They appear to play a most important part in the nutrition of the cell, and, curiously enough, an equally important part in poisoning them. These are called complements or alexins.

Reduction of the Complements in the Blood of Alcoholics.

Abbott and Bergey² find that in alcoholic poisoning these complements are irregularly but distinctly reduced, and they maintain that this reduction accounts, first of all, for the impaired power of nutrition met with in alcoholised animals, on the ground that there are not sufficient compliments to combine with the necessary nutrient proteid or albuminoid substances circulating in the blood. Moreover, the lack of these complements is of importance, from the fact that without them it appears to be impossible for any immunity to disease to be set up in an animal. They offer this as an explanation of the fact that in alcoholism impaired nutrition is first observed; that this is accompanied or followed by an interference with the production of immunity. I have already mentioned that the complement is said to be derived from the white blood-cells of the body, or from the connective-tissue cells, or both, and it is evident that this diminution in the amount of the complement present may be the result of diminished or markedly altered activity of the leucocytes and of certain other cells of the body. In any case, the diminished amount of complement in the blood should be associated with the diminished number of circulating leucocytes observed by Laitinen, and accepted as an

¹ “Croonian Lecture,” *Proc. Roy. Soc., Lond.*, 1900, vol. lxvi., p. 424.

² *Centralbl. f. Bakteriol. u. Parasitenk.*, Jena, 1902, 1 Abt., Originale, Bd. xxxii., S. 260.

indication that the leucocytes are not responding to the calls that have been made upon them in connection with the nutrition and scavenging of the body, and that they are not assisting in the production of the immunity that, under the influence of the poisonous substances generated in the body, should be going on during the course of infective fevers.

We may accept it then that alcohol interferes with the process of phagocytosis ; moreover, that both the microphages and macrophages—the small cells and large cells entrusted with the scavenging work of the body—are rendered less active by alcohol, not only as regards their movement, but also as to their power of taking in foreign bodies and of manufacturing complements. Alcohol plays a prominent part in bringing about degeneration of nerves, muscles, and epithelial cells. It determines the accumulation of waste products in the tissues by “paralysing” the tissue cells, interfering with oxidation and with secretion and excretion. It induces the proliferation of the lower forms of tissues, often at the expense of the more highly developed tissues which, in its presence, undergo marked degenerative changes. It interferes directly with the production of immunity against specific infective diseases, and, reasoning from analogy, it may be assumed that it plays an equally important part in impairing the resistance of tissues to the advance of the active agents in the production of disease that may have already obtained a foothold in the body.

Alcohol and Nutrition.

Since the subject and title of this lecture were selected, Dr. F. Gowland Hopkins, Reader in Chemical Physiology in the University here, has contributed to the literature of our subject a most interesting and impartial study of the chemistry of alcohol in its relation to the body,¹ and I am thus in a great measure relieved from the necessity and responsibility of considering this question in anything but mere outline. Comparing sugar with alcohol as an energy food, Dr. Hopkins points out that if we could utilise all the heat that the alcohol can possibly give, we should still waste 15 per cent. of the original energy of the sugar from which the alcohol was obtained. This is an economic question which those interested in social problems would do well to bear in mind when alcohol is spoken of as a food. We are told that the yeast by which alcohol is produced from sugar obtains the energy that it requires directly from the sugar “by complete assimilation or otherwise ; the resulting alcohol, though still containing a considerable proportion of the original potential energy of the sugar, appears to be itself a source neither of energy nor of nutrition for the yeast : it is an end-product which, when it is accumulated, becomes noxious and inhibits growth.” In view of what we now know as to the general action of alcohol, this is a very interesting statement. It is quite possible, or even probable, that before alcohol

¹ *Med. Temp. Rev.*, London, 1903, vol. vi., pp. 166, 197, 229, 292.

can be utilised as a food substance it may have to undergo very considerable modification in our body. Certainly, as we shall see later, the process of oxidation appears to be one aiming directly at the protection of the tissues, and has to do with their nutrition only indirectly.

Alcohol in the Blood.

In a series of experiments recently carried out, it has been shown that alcohol introduced into the stomach is very readily taken into the circulating blood, and there remains for some time—two to five hours—undergoing little change, and being eliminated by the kidneys comparatively slowly. If a larger quantity than 1 c.c. per kilogramme (12 or 13 drops per pound) of the body weight be given, it has not all disappeared until about the seventh hour. If these experiments are correct, it is a curious fact that although the alcohol given in small doses remains practically unaltered for some time, it disappears very rapidly between the fourth and seventh hours. This prolonged period of inaction, followed by rapid oxidation, does not indicate a profitable utilisation of alcohol as a foodstuff. We are told that alcohol stimulates the flow of the gastric juices, but at the same time interferes with their digestive activity; that it is rapidly absorbed, and that its influence in either direction is probably brief and comparatively unimportant; that its ill effects on the alimentary canal, when given without food, are marked, and that the clinical evidence for the existence of alcoholic dyspepsia is borne out by the experiments of Theohari and Babes,¹ who giving doses of 20 to 30 c.c., observed first a period of increased secretion of gastric juice and then a disappearance of pepsin, these functional changes being associated with histological changes in the gland cell. Hopkins argues that it is easy to understand how even small doses of alcohol, in the absence of food, may set up an unphysiological flow of gastric and pancreatic juices into the alimentary canal, and to account for the recognised bad results of drinking spirits between meals.

The Food Value of Alcohol.

It is customary to measure the value of food by speaking of it as setting free, when it is oxidised, so many Calories of heat, a Calory being the amount of heat necessary to raise the temperature of a kilogramme of water through 1° C., (a pound of water through 4° F.)

In all beer there is a certain amount of sugar and dextrin, or carbohydrate, and Dr. Hopkins states that the energy per pint of pale Burton ale is 210 calories from the alcohol and 97 calories from the carbohydrates, Dublin stout giving 266 calories from the alcohol and 107 from the carbohydrates. He calculates that the potential energy from these constituents of beer, without reference to their real food value, is from 60 to 70 per cent. due to the alcohol, and from 30 to 40 per cent. due to the carbohydrates; and he points out that “although

¹ *Compt. Rend., Soc. de Biol.*, Paris, 1899, p. 821.

the heat value of the carbohydrates is small compared with that from the alcohol, yet a heavy beer-drinker may take every twenty-four hours, in the form of his beverage, enough dextrin and sugar to form no inconsiderable proportion of the carbohydrate which should be present in a normal day's dietary. This carbohydrate is taken, however, under quite special conditions—in constant association, namely, with alcohol simultaneously ingested." He goes on further to say "that the carbohydrate of the beer, together with the circumstances of its simultaneous ingestion with alcohol, is doubtless responsible for the stoutness of the beer-drinker. He exhibits not only the fatty degeneration of internal organs which is common to all forms of alcoholic excess, but a deposit of fat which, though abnormal in amount, is present in a normal *dépôt*—in the subcutaneous tissues" of the animal body.

Allowing for all this, Hutchinson¹ points out that as a food alcohol is open to the objection that is very costly, "even in Bavaria the land of cheap beer, it has been calculated that alcohol in that, its least expensive form, is eight times dearer than bread, from the point of view of the amount of heat yielded."

As we have already seen, one of the most dangerous and characteristic features of the attack of alcohol on the tissues is its predilection for the central nervous system, the nerve cells first being excited, then rapidly passing through a period of depression often very marked and prolonged. As it has been well put by Hopkins, "the excitation, and the more pronounced depression, are felt first of all by the cells of the cerebral cortex, so that the intellectual functions and the finer aspects of motor and vasomotor co-ordination are first affected. Later in time the influence extends to lower centres, co-ordinative power is lost, and the respiratory and vasomotor centres are profoundly affected.' Schmiedeberg points out, however, that the apparent stimulation of mind and body first noticed after taking alcohol must be due to an early paralysis of the highest centres, "whereby reflective power and judgment are lost and the normal inhibitory, control over the lower centres by the higher is destroyed."

Although alcohol picks out the nervous tissues specially, it still exerts a great influence on tissues in which nutritive changes go on more actively than they do in the nervous tissues, and it is strongly insisted by those who have collated recent observations on this point that, in tissues unaccustomed to the presence of alcohol, its administration is almost invariably followed, for a short period at any rate, by increased nitrogenous waste. Hopkins maintains, however, that, "unfortunately, the slower reactions of the less sensitive tissues are, in the case of any poison, difficult to follow step by step: and, in the case of alcohol, there is a gap in our exact knowledge between the phenomena of the immediate and pronounced reaction of the central nervous system, and the equally obvious, crude, anatomical changes,

¹ "Food and the Principles of Dietetics," Lond., 1902 p. 333.

in quite other tissues, found *post-mortem* after alcohol has done its worst. These crude changes ultimately found make it certain that these other tissues have suffered, step by step, even from the first, but their reaction and the disturbance of their functions have at first been slight, and not easily demonstrated by experiment or observation."

How is Alcohol Oxidised in the Body?

For long there has been great difference of opinion as to whether alcohol is oxidised in the body or not, and it is only as methods of analysis have been perfected that physiological chemists have been able to prove that it is oxidised in the body. When given in very large quantities the oxidation is undoubtedly incomplete, though Atwater and Benedict¹ have proved that if $2\frac{1}{2}$ ounces be administered daily the whole, except about 2 per cent., is oxidised, this 2 per cent being excreted unaltered. It must be remembered, however, as Hopkins points out, that this oxidation may be only partial—that is, that the alcohol may not be broken down to its ultimate products of carbonic acid gas and water. The process of oxidation, indeed, may be one in which the alcohol is broken down from its toxic condition to one not so injurious to the tissues, though even this process can never go on in the case of a poison without some damage being inflicted on the tissues in which it occurs. The most injurious toxins or poisons, such as those produced in diphtheria and tetanus, undergo oxidation in the tissues of most warm-blooded animals, and it is always difficult to recover such substances from the tissues when once they have been introduced. Chemists tell us, moreover, that amyl alcohol is four times as poisonous as the common ethyl alcohol, yet, says Hopkins, this is oxidised in the body; but, "the substance is so toxic that the tissue can deal only with a comparatively small amount. The difference between common alcohol and amyl alcohol is purely a matter of degree, and in one of its aspects the oxidation of alcohol is the process of protection on the part of the body against the poison." Continuing, I cannot do better than again quote the same writer, to the effect that "any substance oxidised in the tissues must yield energy to the body; and it might happen that such a substance, though poisonous in large amounts, could, in smaller quantities, yield its intrinsic energy in such a way as to be useful. It is not an unthinkable proposition that in this sense a substance may be at once a poison and a food. The question is whether, at a certain dose, the toxic action can become sufficiently slight, and the yield of energy sufficiently important, for the noxious substance to become actually useful." In the case of amyl alcohol the toxicity is so great that the most elementary experiments are sufficient to prove that it acts so powerfully as a poison that any nutrient power it may have is entirely overshadowed. In the case of ethyl (or ordinary) alcohol, however, taken in small quantities, the toxic effect is so subtle and apparently so slight, whilst the temporary feeling of well-being is so distinctly

¹ *Mem. Nat. Acad. Sci.*, Washington, 1902, vol. viii., 6th Memoir.

marked, that it is difficult to convince anyone that the action can be deleterious. Certain physiologists maintain, moreover, that the proportion oxidised is so important that it actually constitutes a food-stuff, though all acknowledge that even if it is a foodstuff, it can play no part in building up the tissues! It merely provides heat and interferes with the breaking-down of the tissues. Hopkins states, too, as I have insisted elsewhere, that the mischievous effects produced by small doses of alcohol "are exceedingly difficult to observe and register from day to day, though their consummation may ultimately bring about profound mischief. Metabolism experiments upon man, at any rate, are almost necessarily of brief duration, and their brevity limits their application. The results answer certain aspects of the question, but cannot be extended to others which may be the more fundamental." Atwater and Benedict's experiments seem to show that in the small quantities they used ($2\frac{1}{2}$ ounces) alcohol may replace a proportion of fat in the diet, a portion that would yield about 500 calories, "so that under special conditions alcohol may act as a fat sparer." It is well known, too, that fat may act in the same way; but Rosemann¹ (quoted by Dr. Hopkins) is clearly of opinion that alcohol given to a patient unaccustomed to this substance invariably causes an increased loss of nitrogen, not only when it is given to replace some of the carbohydrates in their dietary, but also when it is given in addition to the dietary on which the patient experimented upon was originally giving out a steady quantity of nitrogen. In a series of experiments carried out by Miura², this increased waste of nitrogen was always observed when alcohol was given, whether it replaced, or was added to, carbohydrate—in fact, it induced a condition somewhat similar to that set up in starvation. Even when a considerable amount of alcohol (nearly 1,000 calories energy value) is given to take the place of carbohydrates, the loss of nitrogen still goes on—that is, there is a direct breaking-down of the tissue during the administration of alcohol. This is ascribed to a direct poisonous action upon the tissues, for as soon as the alcohol is stopped the nitrogenous waste rapidly diminishes.

Experiment shows that alcohol given for a short time only to a person who is not accustomed to its use has no effect in sparing the proteid, but rather brings about an increased breaking-down of the tissue, so that the body, instead of growing, wastes. When alcohol is given for a longer period, the loss becomes somewhat less, and after a time the tissues seem to be able to behave as usual, even in the presence of alcohol. It is maintained, therefore, by some that two or three ounces of alcohol added to a diet on which the patient is maintaining weight at a constant level, will in time lead to an increase in weight, this increase in weight, it is held, being the result of the action of alcohol. These experiments, however, were all carried on with comparatively small quantities of alcohol; moreover it is recognised

¹ *Pflüger's Archiv*, Bonn, 1901, Bd. lxxxvi., S. 307, and xc., S. 557.

² *Zeitschr. f. klin. Med.*, Berlin, Bd. xx., 1892.

that even when alcohol is not given, a deficiency of either carbohydrates or proteids may allow of the attainment of an equilibrium of weight, but, of course, at a somewhat lower scale. In patients accustomed to the use of alcohol, the results are not the same, and in considering the various sets of experiments this fact must be carefully borne in mind. Offer¹ found that a healthy man not accustomed to take alcohol, on a diet of sufficient though not high value lost 0·3441 gramme. Then a quantity of alcohol, about 3½ ounces (equal to 700 calories), was given daily for a period of eight days. For the first four days there was a loss of 1·1689 grammes, but in the second four days a slight gain of 0·2335 gramme. Then the diet was given without alcohol, and there was a loss of 0·0110 gramme; but when fat was added to the diet (75·3 grammes, equivalent to the alcohol calories), there was a gain of 1·5654 grammes. So that here the immediate effect on the addition of alcohol was a loss of nitrogen followed by slight gain, but as soon as it was replaced by fat a very marked gain was observed. In this instance, at any rate, alcohol could not be said to provide anything like the equivalent of energy that the fat supplied.

Returning to Atwater and Benedict's experiments, perhaps the most important and complete set of experiments yet carried out, we find that a total abstainer remaining quietly at rest throughout the day on a definite diet at first gave evidence of a slight loss of nitrogen. This loss ceased, however, as soon as fat or carbohydrate was given, and ultimately there was a slight gain. When the fat was replaced by alcohol, this slight gain was immediately followed by a loss, which on the third day was somewhat marked. Hopkins, criticising these experiments, very pertinently remarks that, as the observations were

ADDITION OF	NITROGEN BALANCE IN GRAMMES		
	1	2	3
Fat	—1·8	—0·3	+0·4
Alcohol	+0·1	—0·9	—2·1
Carbohydrate	—1·3	—0·8	—0·1
Carbohydrate	—0·3	—1·0	—1·1
Alcohol	—1·6	—2·8	1·9
Fat	—1·0	—0·2	—·1

continuous, the effect of the alcohol ran over into the carbohydrate period, and similarly the effect of the fat ran on into the period when alcohol was being given, and during this latter period, when the patient was put to work, the loss was always greater than was the loss under fat.

¹ *Centralb. f. Stoffwechsel u. Verdauungs Krankheiten*, No. 22, p. 573.

Alcohol not a Food on which to do Work.

Alcohol, therefore, is on the whole a poorer substitute for ordinary foodstuff when a man is at work than when he is at rest. In an individual accustomed to take alcohol there was a gradual loss of nitrogen during the whole time that the alcohol was being given—a loss greater than when it was withheld. Indeed, as the results of all these experiments, Professor Atwater acknowledges that alcohol is incapable of preventing nitrogenous waste or of acting as a nitrogen sparer.

Commenting on this, Hopkins says: "This is the more significant, because, as I shall urge later, the experiments were done under conditions likely to minimise the toxic effect as much as possible"; and he further points out that, even admitting that "in a certain limited sense the body may make use of the potential energy of alcohol more economically" than we have hitherto suspected, there is still strong doubt "as to whether the experiments show that the toxic influence of the substance is ever in abeyance, and this, after all, is the essential matter if we are discussing food values in a practical sense." Nothing that Atwater has written would, I think, warrant us in supposing that he holds the practical aspect of the alcohol question to be effected by his experiments, though Duclaux,¹ somewhat unwarrantably, going further than the authors of the above experiments, says that they now "enable us to say that not only is alcohol not a poison, but that it ought to be placed alongside starch and sugar; it even surpasses them in alimentary value, because, weight for weight, it contains more energy. This is a complete change in our point of view as regards man; and, as to animals, the time is coming when alcohol will enter into all lists of their food rations."

Is Alcohol a Proteid Sparer?

Dr. Hopkins, in a very able summary, contends that the American experiments do not yield conclusive evidence that alcohol is a proteid sparer; that they were not sufficiently prolonged to enable the observers to determine whether the alcohol ultimately had any injurious effect upon the tissues; that no real immunity against the toxic action of alcohol can ever be acquired; and that even where there is no disturbance of the nitrogen balance there may be marked alteration in the nature of the nutritive processes, as evidenced by the observation of Rosenfeldt and Chotzen;² that in the equilibrium obtained during the administration of alcohol there is excretion of uric acid; and that this appearance of an increased amount of uric acid indicates increased tissue changes. He further shows that the temporary increased nitrogenous excretion may be the result of increased metabolic activity, whilst the resulting diminution in nitrogen excretion may be the result of a depression of the nutritive

¹ *Ann. Inst. Past.*, Paris, 1902, t. xvi., p. 858.

² *Therapie der Gegenwart*, February, 1900.

activity of the tissues, corresponding to a similar depression that occurs in the nerve cells after a short period of excitation, and that such a depression of activity would be a very different thing from a physiological sparing of the tissues. "Actual retention of nitrogen as an effect of such abnormal activities in the cells would imply the production of abnormal nitrogenous products in the body and the phenomena of chronic alcoholism, as, for instance, the increase of fibrous tissue in organs, show that such production is to be thought of."

Alcohol Valueless when given with other Foods.

Schnyder¹ maintains, as the result of the study of muscular activity during the period that alcohol is given in comparison with that during the period in which it is withheld, that in the absence of food alcohol may be utilised to a certain extent by the tissues, but that in thus utilising it the tissues are damaged; moreover, when other food is given at the same time alcohol is not utilised as a source of work, for it is found that when normal food is taken in sufficient quantity to supply energy for the work to be done, the alcohol appears to afford no energy to the muscles. On the other hand, it appears to diminish their activity, and to interfere with the total volume of work done by them. In any case, accepting the most favourable interpretations of the experiments of this observer, only from 12 to 15 per cent. of the total daily supply of energy to the body could be derived from alcohol, such energy being supplied at most uneconomical cost, and he closes by saying: "I should like to point out once more that we are not called upon to doubt the accuracy or the intrinsic scientific interest of the more recent data regarding the fate of alcohol in metabolism; at the same time we should recognise how small is their bearing upon practical dietetics." Hutchison,² though not going so far, comes to a similar conclusion.

Professor Chauveau,³ in his experiments on the dog kept for a long time under observation, concluded that to an animal at work alcohol is *not* a force-giving food, that when alcohol is given in place of sugar after an equilibrium has been obtained there is a diminution in the absolute amount of muscular work done, that there is an interference with the process of repair, and that such work as is done is done at an added cost to the individual.

Professor Atwater, summing up his own work, says: "We ought not, on the one hand, to teach that alcohol is a food in the common-sense of the word, and, on the other, we *cannot discuss* its physiological action thoroughly without recognising its nutritive value. We must point out its limits. If we say that alcohol is a food and maintain it, children are induced to think of it as they do of bread and meat, and we encourage them to use that which they had better avoid." He

¹ *Pflüger's Archiv*, Bonn, 1903, Bd. xciii., S. 451.

² "Food and the Principles of Dietetics," London, 1902. pp. 323—325, 328—333

³ *Bull. Acad. de Sc.*, Paris, janvier, 1901 (see Legrain's Paper).

goes on to say that the child and the adult, as long as they have good health and don't need alcohol as a drug, are better if they do without it; and that "if the oxidation of alcohol in the body *could* produce heat and energy, it is none the less proved that it can produce much evil, and that it should not be called a food in the proper sense of the word. The net result of its use is damage, not advantage. It is like a man endeavouring to increase his income with the result of spending more than he gains, and becoming poorer in the end."

Dr. Legrain¹ points out that it is not enough that a food should be composed of the three or four elements necessary for the production of tissue and energy in the body, and that it should be oxidised and metamorphosed in the system, or that it gives rise to no trouble when taken in moderate amounts for a short time. It must also be digestible, must do no harm to any organ or the system as a whole when taken in moderate but repeated quantities—in fact, that its useful action should not be neutralised by its injurious effects.

Even men who believe that alcohol is a food of some sort recognise that a healthy man cannot subsist on alcohol, and that he certainly needs none at all, even when fatigued, the fatigue of a healthy man soon passing off with rest, ordinary food, and natural sleep.

Alcohol in Training.

At one time, when I was a much younger man than I am now, and for personal reasons that some of you may appreciate, I paid considerable attention to the theory and practice of training. Then, when my active athletic days were over, and during the years I was Secretary and President of the Edinburgh University Athletic Club, I had frequent opportunities for studying methods of training, of discussing it with men and of advising them on such matters, and I may say at once that it was my experience that many even of those who at first did not agree with me would gradually come round to my way of thinking as soon as they really settled down to work.

A man, to be fit, must have every part of his body and brain thoroughly well nourished and working under the most favourable conditions, and this thorough nourishment and these most favourable (normal) conditions I was soon convinced can never be present in those who use alcohol, even in comparatively small quantities. The fact that alcohol lowers the temperature, diminishes the amount of carbonic acid gas given off from the lungs, and apparently interferes somewhat with the breaking-down of the tissues, is to my mind evidence sufficient that there is an interference with the general processes of nutrition and excretion; and this being the case, the more severely we leave it alone the better for our "condition." Further, I maintain that what holds good as to training is equally

¹ See full summary in *Med. Temp. Rev.*, 1903, vol. vi., pp. 100-104 see also Dr. C. R. Drysdale, same Review, vol. vi., pp. 215-220

true in regard to our general staying power—a power so essential to success in life's race

Professor Hueppe¹ of Prague, maintains that for people who are subjected to prolonged muscular exertion total abstinence is a necessity. His experience coincides with my own, that athletes and gymnasts are always in better condition as total abstainers than when they are taking alcohol, and that in rowing total abstainers have the best chance of success. He points out that as the result of one inquiry amongst 60 mountain climbers it was found that 62 per cent. of them thought that total abstinence was absolutely essential, 8 per cent. considered that a moderate regular use of alcohol was beneficial, and the remainder saw no harm in its occasional use. We can also call in to corroborate Professor Hueppe, himself a great athlete, Montague Holbein,² one of the best all-round athletes we have ever produced in this country—a runner, a walker, a swimmer, and a cyclist—who ends up his statement as regards his methods of training by saying: “Before a big swim I try to get my muscles into the pink of condition; I like to walk thirty miles a day three times a week, to cycle sixty miles a day on three, and, on the three days of the week that I am not walking, to swim for five or six hours. I make only a very slight change in my diet, eat less vegetables and more meat than usual, and I never drink or smoke.”

Dr. Hutchison³ and Dr. Ridge,⁴ writing on this subject, both point out that the object of a trainer is to increase the muscular strength of the man under his charge, to remove superfluous water and fat, and to get rid of waste matter as quickly as possible, and to improve the “wind” and staying power, which really means, says Dr. Ridge, “to increase the muscular power of the heart muscles and the aerating function of the lungs, that they may be able to maintain the circulation under the extra demand of great exertion.

To accomplish this it is necessary that one in training should not eat too much, and thus overload and tax the digestive organs; and they should not eat too little to replace the waste tissue and supply material for the growing muscles and fuel for the work that they have to do”; and, lastly, that they should take nothing to interfere with digestion or to retard the changes in the tissues.

Let us consider for a moment why men who have to undergo the most prolonged and arduous work so frequently avoid alcohol almost as if by instinct. To begin with, “tissue sparing” is of little value, one of the great aims of the trainer being to build up the

¹ *Bericht ü d. IX internat. Kongress gegen d. Alkoholismus abgeh. in Bremen, 1903*, Jena, 1904, S. 36 and *Pflüger's Archiv*, Bonn, 1903, Bd. 95, S. 447.

² *Pearson's Magazine*, London, 1903.

³ “Food and the Principles of Dietetics,” London, 1902, p. 39.

Med. Temp. Rev., London, 1903, vol. vi., p. 190.

tissues of the body steadily and systematically. There must be no working by fits and starts; there must be a steady and regular supply of easily-digested and readily-assimilable food, the cells of the tissues must carry on their work under the most favourable conditions, and the waste products should be readily removable and at once removed. Alcohol, even in "moderate" quantities, interferes with all these processes.

Then, from what we have seen, alcohol introduced along with other food is practically so much luggage for the tissues to carry, so much dead weight that has to be got into and from the body at the expense of much tissue energy. It supplies little or no additional continuous energy, but it does add an additional amount of waste material, which has to be excreted, and so must add to a certain extent—in many cases to a large extent—to the work of the excretory organs. It not only produces additional waste material, which has to be excreted, but it also acts directly by interfering with the function of excretion, and thus becomes, I believe, one of the most common causes of staleness with which a trainer has to contend. Alcohol exerts a direct action upon the heart muscle, perhaps a more important one than upon the ordinary muscles of movement. Even in comparatively small quantities, as we have seen, its action upon the heart is a peculiar one, gradually causing a condition of dilatation, owing to the fact that at each beat there is imperfect contraction; some blood is left in the organ, and in time, if the beat becomes very rapid, there is a distinct diminution in the amount of blood passed through the slightly dilated cavities and therefore through the lungs, the individual loses his wind, and the results of long and otherwise careful training may be almost entirely nullified.

Such a condition of the heart has probably quite as much (or more) to do with staleness as has the accumulation of waste products in the other muscles. Further, a man to be keen must have a good, steady flow of blood to his brain, and the nerve cells must not be exhausted either by overwork or by the action of alcohol. The accumulation of waste products in and around these cells is just as deleterious as when it takes place in the muscles, and a man may feel slack and stale simply because of the changes that have taken place in the nerve cells as the result of the administration of even comparatively small doses of alcohol. The temporarily increased blood-pressure induced, giving rise to a temporary feeling of well-being, no doubt may lead a man to suppose that a champagne dinner has done him good; but the reaction coming on afterwards is often very marked, with the result that he is not capable of doing the best that is in him, often just when that best is needed. Whatever may be the ultimate result of the experiments of physiologists with small quantities of alcohol, of one thing I am thoroughly satisfied from my own experience, and from the experience of men with whom I have

trained, that the man who is in strict training should never take alcohol under any circumstances. I know that in this I am not following orthodox opinion, and I shall be told that I am dogmatising; but give me two men of equal powers, or two boat crews of equal merit as regards strength and watermanship to begin with, train them together, and at the end of the period of training the man or the crew that takes no alcohol will win every race.

Schenk¹ and Parkes both maintain that where work is being done strain is not relieved by the administration of alcohol, but increased; and Schnyder (*op. cit.*), working with small groups of muscles, found that although a certain amount of energy may be derived from alcohol if it is given to the experimental subject whilst fasting, this substance cannot be utilized to the same extent as can food of equal calorific value. If sufficient food be given along with the alcohol, this latter substance appears no longer to have any value as a food. Moreover, alcohol appears to exert a "paralysing influence, and leads to a diminution of functional capacity," from all of which this observer argues that, under such conditions, not only is alcohol useless in regard to muscular activity, but, even in small quantities, is actually harmful. When no other food is available, it may have some slight value, but the tissues have to work hard and to endure much in order to convert it to their use; so that in spite of the fact that it may have some value if the patient is fasting, Schnyder strongly condemns its administration, and concludes that "we fortunately possess a number of other foods which have a simpler and safer favourable effect on our muscular strength than the extremely doubtful one of alcohol."

Alcohol and Hard Work and Exposure.

In training it is of the highest importance that the digestive functions should be doing their work as rapidly and as well as possible, and anything that interferes with or disarranges the functions of organs which have to prepare and assimilate food should be carefully avoided. Dr. Molinelli,² who was with the Duke of Abruzzi on his "Stella Polare" expedition, writing on this point, says: "Without wishing to deny that alcohol may possess the property of a heat-giving food which physiologists, hygienists, and the world in general have ascribed to it, it would have been careless to overlook its harmful action on important organs of the animal body, especially the gastric mucous membrane and the liver." In support of his contention he quotes Rubner,³ one of

¹ *Der Alkoholismus*, Dresden, 1900, S. 87 (cf abstract in *Med. Temp. Rev.*, 1903, vol. vi., p. 154).

² In the Duke of Abruzzi's "Die Stella Polare im Eismeer, erste Italienische Nordpolexpedition," 1899-1900, Leipzig, 1903.

³ From Leyden's "Handbuch der Ernährungstherapie," Leipzig, 1898, Bd. i., S. 44.

Germany's greatest authorities on dietetics, to the effect that the feeling of warmth after taking alcohol is falsely ascribed to the production of heat. The sensation of warmth does not prove an increased production of heat, but only an increased flow of blood to the skin. By calorimetric measurement of the heat given out by the human arm, he says: I have not been able to prove that there is any increased heat radiation after taking alcohol, in spite of the increased sensation of warmth."

"One may say," writes Molinelli, "that the rôle of alcohol as a tissue-sparing material is played out. Arising from this false notion its use was recommended to those who had to perform heavy muscular work, such as workmen or soldiers. Fortunately, newer researches have set this notion right, and the action of alcohol has been brought back to its true significance as that of an agent stimulating the nervous system. Moreover, on the artificial temporary stimulation by the alcohol, there follows a reaction, a diminution of power, and a relaxation of the mental faculties which would have been injurious to us in the highest degree, as we needed to exert unceasing attention, watchfulness, and alertness in order to cope with all the dangers surrounding us. In the daytime we drink water and coffee, or water only,"

What is a Moderate Amount of Alcohol?

It has long been a bone of contention, not only amongst the laity, but also amongst medical men, as to what dose of alcohol should be considered a moderate and sufficient daily quantity; it is a curious and significant fact that the more the matter is gone into and the more fully the question discussed, the smaller becomes the allowance. Not long ago a couple of ounces was looked upon as the amount that could safely be taken by those who wished to take it in moderation. That minimum has gradually been cut down, and now, in a report issued by the German Society against the use of intoxicating drinks, and contributed to by physicians, pathologists, physiologists, and hygienists of Switzerland and Germany, Fraenkel of Halle, the editor, states that 1 to 1½ ounces of alcohol per diem is probably a harmless quantity, but the *regular* use of even this quantity is, he says, not to be commended. "Alcohol in any form, as brandy, wine, or beer, and even in relatively small amounts, is a poison to the human body. If alcohol has an effect at all of a strengthening or nourishing kind (which is doubtful), it is only so to a very limited extent, and is of no practical importance." Moreover, he says the only truly moderate man, or one entitled to call himself so, is he who does not take spiritous liquors every day, drinking his wine or his beer, but partaking of it only occasionally, and even then within the above-prescribed limits. Max Grüber, successor to Pettenkofer as Professor of Hygiene in the University of Munich, goes, perhaps, even further than Fraenkel, and records his opinion in

the following terms: "I find there are absolutely no scientific grounds for indicating a given amount of alcohol as harmless, and a matter of indifference if it is given habitually. On the contrary, it seems to me to be in the highest degree probable that the regular use of a much smaller amount than 1 to 1 $\frac{1}{4}$ ounces (the amount mentioned by Fraenkel) does harm to the vast majority of mankind." To anyone who has come in contact with the pathologists and hygienists of Germany during the last few years nothing is more striking than their attitude on the alcohol question. In many cases they are not what we call pledged abstainers, but they are exceedingly abstemious men, and, as I know from personal experience, go for periods of weeks or months without taking alcohol in any form, certain of them making it a definite practice to abstain entirely from alcoholic beverages during the periods of the year in which they are doing their work. With the social customs of their country, they do not abstain completely on festive occasions, but they will tell you that they look upon the harm that they then receive as a price they have to pay for their participation in social functions.

What is Chronic Alcoholism?

The experiments of Kürz and Kräpelin¹ show that the foundations of chronic alcoholism are laid much sooner than is generally supposed. These observers say that a single dose of 80 grammes of alcohol (2 $\frac{4}{5}$ ounces) does not pass off quickly and perfectly, but leaves behind an after-effect which lasts more than twenty-four hours. If a similar dose be given at the end of each twenty-four hours a gradual increase of alcoholic effect is produced, which must be looked upon as the commencement of chronic alcoholism. This becomes marked, after twelve days of such treatment, by a depreciation of faculty to the extent of 25 to 40 per cent.

Not long ago I heard Dr. Glover of London say² that Sir William Jenner, who was not a teetotaler, once said to him: "I have come to the conclusion that if a man is to work hard he must eat moderately and drink nothing." Need more be said?

Dr. C. K. Millard, Medical Officer of Health for Leicester, in his Annual Report for 1902, sums up the whole question of alcohol and its relation to the public health in the following remarkably pregnant statement: "Speaking as a medical officer of health, I can say that if I were given the choice of the abolition on the one hand of the evil of drink, and on the other of all the other various preventible

¹ See summary in *Med. Temp. Rev.*, 1903, vol. vi., p. 158. These researches had, in part, already appeared in Kräpelin's "Neuere Untersuchungen" (*Internat. Monatsschr. z. Erforsch. d. Alkoholismus*, Basel, 1899, SS. 324-326); see also Kräpelin's "Psychol. Arbeiten," 1901, Bd. iii., and "Ueber die Beeinflussung einf. psych. Vorgänge durch einige Arzneimittel," Jena, 1902.

² In a discussion on the Medical Problems of Alcoholism at a meeting of the Islington Medical Society (*Lancet*, London, 1903, vol. i., pp. 1670-1672).

influences adversely affecting the public health on which medical officers are at present concentrating their efforts, I would choose unhesitatingly the abolition of drink, as being greater, by far, than all the others combined."

How true this is only those who have gone into the question can know, but each one of you may, by a study of the question, soon convince himself or herself that Dr. Millard has not gone one word beyond what is amply justified by facts.

It is evident that wherever we have accurate data on which to base a conclusion no verdict can be given in favour of alcohol. Even in the case of the very small doses in which it is sometimes used (although certain physiologists have departed from their custom of requiring facts and experiments to support the position they maintain and have accepted use and wont and "general experience" in their stead), the verdict must be "non-proven." On the main question Physiology and Pathology now speak with no uncertain voice, and taking into account the enormous amount of moral, physical and intellectual shipwreck made by alcohol the temperance propaganda is justified ; it must go on and gather force. Temperance workers by the continued study of the effects of alcohol and by the diffusion of the knowledge so gained amongst those who are growing up to take an active share in the conduct of the affairs of the nation, will be able to diffuse a more accurate conception of the rôle of alcohol in our national life, and possibly to lead our budding legislators to forward measures to counteract its evil effects.



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